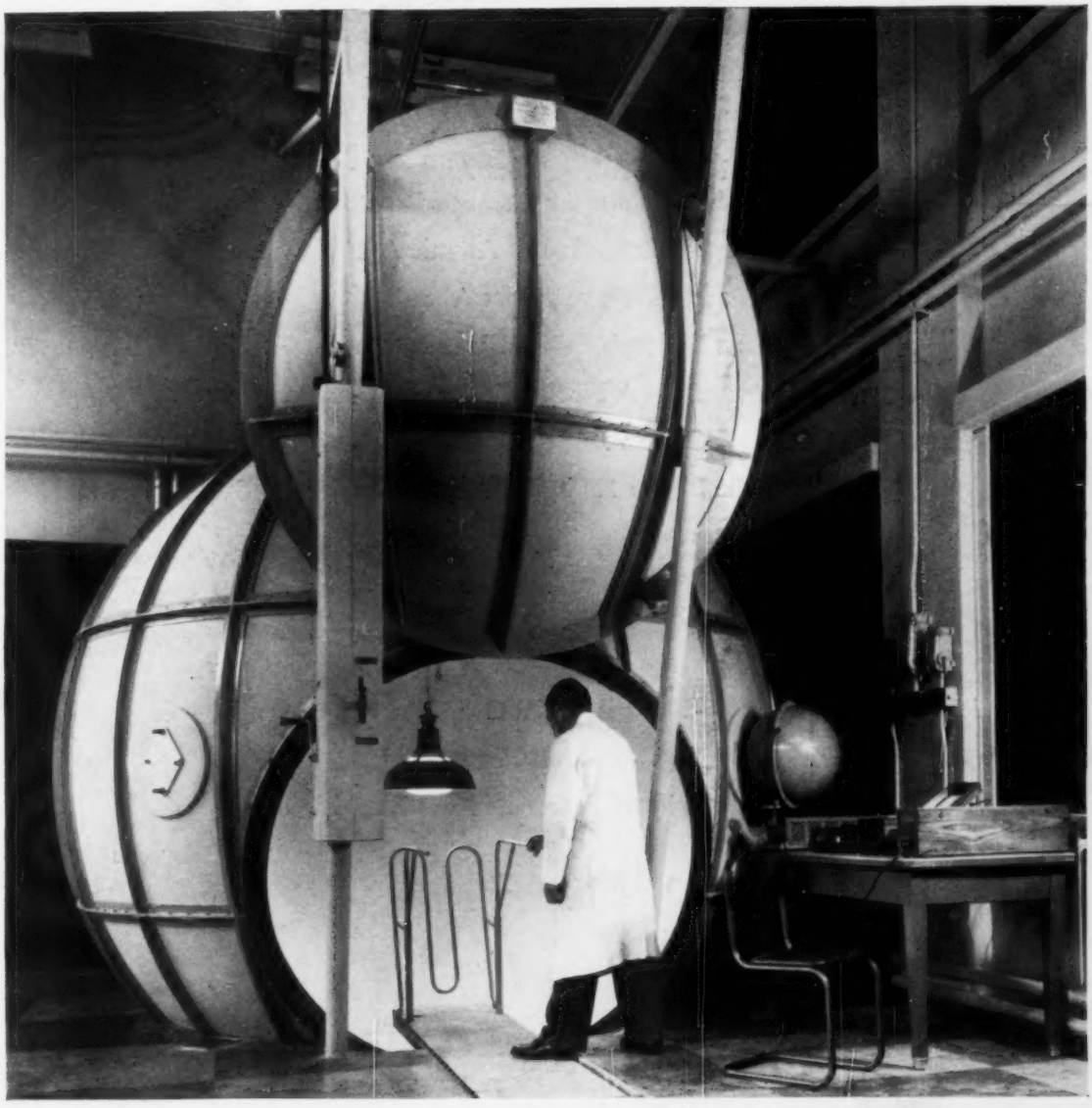
THE BEAMA JOURNAL

MAY 1959



A photometric integrating sphere in the research laboratory of a British lighting firm

A QUARTERLY REVIEW OF

BRITISH ELECTRICAL AND ALLIED ENGINEERING

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A QUARTERLY REVIEW OF BRITISH ELECTRICAL AND ALLIED ENGINEERING

Volume 66 : Number 2 : May 1959

Editorial

British Electrical Exports in 1958

Now that the complete figures are available, we can extend the brief comment on this subject in our February issue.

Taking the overall picture, the value of electrical exports in all categories was £276·4 million. Compared with 1957 this shows a very small drop of only 1 per cent, and for this there was a specific reason: a fall of £10 million in the export of cables and wires due to the fact that in 1957 British manufacturers of these products received very large and, what were known at the time to be, unrepeatable orders from the USA. As against this, nearly every other category of electrical products showed an increase, with the biggest rise of all occurring in generating equipment and transformers—up by £3·9 million and £2·1 million respectively.

These figures are particularly noteworthy when viewed against the background of a decline in world exports of electrical machinery and appliances of 1·6 per cent in 1958, and although the year proved to be a difficult one for British export trade in general, the electrical industry more than held its own.

It should always be remembered that the export figures in HM Customs and Excise Bill of Entry Returns (from which the figures quoted here are taken) cover 'direct' exports only and do not include the large content of electrical equipment embodied in or attached to other engineering products. If it were possible to calculate the value of such 'indirect' electrical exports, the total of the industry's export effort would certainly reach—and probably exceed—£300 million.

Commenting on our exporting industry, the retiring Chairman of the BEAMA Council said at the recent annual general meeting:

'The responsibility of winning export trade against world competition is shouldered primarily by the manufacturing industry. I mention this because there is insufficient appreciation in certain quarters of the difference between the role of the electrical manufacturing industry and the role of the electricity supply industry.

'For the last fifty years there has been the closest co-operation between the two branches of the industry and prospective buyers from overseas have been able to see what Britain has to offer by an inspection of the supply authorities' power stations, and transmission and distribution systems under working conditions. This has helped our manufacturing industry to face world competition and we have faced it successfully.

'That the level of our prices is competitive has been recently emphasized by the contrast between our prices and those of American manufacturers in their home market.

'With leadership in research and development and ability to meet foreign competition, further expansion of our trade overseas depends upon the extent to which solutions can be found for financing a greater number of British capital projects abroad.'

The Season of Exhibitions

Every year the British Electrical and Allied Industry is greatly occupied with exhibitions, principally in London, but also with several important though smaller events at various centres throughout Great Britain.

The first in this year's calendar was the Physical Society's exhibition in January, an event which differs markedly from the others in that it is essentially a scientific display by a learned society. Elaborate stand designs are barred and the greater proportion of the exhibits are uncommercial in character, though they often form the basis of commercial developments—now or in the future. It is a tribute to the prestige of this old-established event, and a significant proof of the great expansion of the research and development activities of the industries concerned, that the number of exhibitors has steadily increased year by year.

Next came two major exhibitions in March which are reviewed in this issue: the event sponsored by the Association of Supervising Engineers and popularly known as the 'Electrical Engineers' Exhibition', and the Ideal Home Exhibition organized annually by the London *Daily Mail*.

The first-named is the electrical industry's biggest annual exhibition, and its phenomenal growth in only nine years provides its own testimony to the vigour, vision, and energetic salesmanship of Britain's electrical

industry. It is essentially a trade exhibition; it does not set out to attract or cater for the general public (although there is much in it to interest and inform the electricity-using public).

By contrast, the Ideal Home Exhibition is a great public spectacle which annually attracts well over a million visitors during its run of about three weeks. It is devoted entirely to the home and everything embraced within that definition. What could be more natural—indeed inevitable—that over the years the many domestic applications of electricity should occupy more and more space and attract even greater public interest? That was undoubtedly the trend this year and is one of the highlights of our review of the exhibits in this issue.

By the time these words appear in print, another big exhibition will have come and gone—the Engineering, Marine, Welding, and Nuclear Energy Exhibition held during the last fortnight in April. We hope to review it in our August issue, with special reference to the Welding Section (which forms in effect an exhibition within an exhibition), coupled with a survey of the latest progress of the British welding industry as a whole.

The British Electrical Power Convention in June will again be accompanied by its own exhibition. Since this event moves to a different venue each year and permanent exhibition halls do not exist in most towns, the exhibition must needs be housed in a temporary wood and canvas structure—a circumstance which severely limits its size. But within that limitation it offers an interesting and informative cross section of the industry to people who would otherwise never have an opportunity of seeing many of the electrical products and applications displayed there.

Interspersed among these exhibitions are many others which have some link with our industry: for example, the Factory Equipment Exhibition, the Plastics Exhibition, the International Transistor Exhibition and Convention, the International Hospital Equipment Exhibition, and many others in various provincial centres.

While we obviously cannot find the space within the four quarterly issues of THE BEAMA JOURNAL to report all these events, we will do our best to keep our readers overseas in touch with the highlights of British electrical activities revealed at the exhibitions.

The late Sir Claude Gibb

The news of the sudden death of Sir Claude Gibb, KBE, FRS, Chairman and Managing Director of C. A. Parsons and Co Ltd, while on a business trip to the USA on January 15, 1959, was received with the deepest regret. His career in the electrical industry had been long and distinguished. As well as being Chairman and Managing Director of Parsons, he was Chairman of the Nuclear Power Plant Co Ltd, the Anglo Great Lakes Corporation, Parolle Electrical Plant Co Ltd, and until October 1958 Chairman of A. Reyrolle and Co Ltd.

An Australian by birth, he took his Bachelor's and Master's degree in engineering at the University of Adelaide before coming to England in 1924 to gain practical engineering training with C. A. Parsons. Starting as a fitter in the erecting shop, in five years he was appointed to the Board of Directors. In 1937 he became General Manager and in 1945 Chairman and Managing Director.

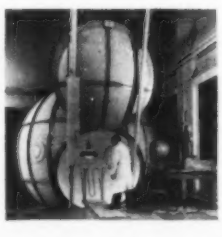
After distinguished service with the Ministry of Supply during the war years, Sir Claude returned to Parsons and immediately concentrated on the expansion of the firm's export market, where much of the trade in turbogenerators lay. Under his guidance Parsons expanded their works and to-day employ nearly twice as many people as in 1945. The size and output of generating plant has risen steadily, culminating in an order for the supply of the largest turboalternator in the world—the 550 MW set for the Thorpe Marsh power station.

Sir Claude's influence in the nuclear power field has been considerable. He played an important part in the discussions which led to the construction of Calder Hall, and in 1955 he was largely responsible for the formation of the Nuclear Power Plant Co Ltd—a consortium of eight firms combining the specialized knowledge and experience essential for the design and construction of complete nuclear power stations. The Group is now building one of Britain's four new nuclear power stations, and last year secured the contract to build the Latina station near Rome—Italy's first nuclear power station and the first large nuclear power export contract in the world.

The foundation of the Anglo Great Lakes Corporation Ltd is another example of Sir Claude's foresight and organizing skill. British nuclear power stations are graphite moderated, and when in 1956 Britain's nuclear power programme was planned, it became clear that an additional supply of high density graphite would be required. It was to this end, largely under Sir Claude's guidance, that the Corporation was formed. When completed, the plant will produce some 10,000 tons of nuclear quality graphite a year.

He delivered many papers to learned societies and technical conferences, travelled widely, and received many honours during his career. In 1942 he was made a Commander of the British Empire, in 1945 he was knighted for his services during the war, and in 1956 he was made a Knight Commander of the British Empire. He was elected a Fellow of the Royal Society in 1946, and was awarded the Thomas Hawksley Gold Medal of the Institution of Mechanical Engineers in 1932 and again in 1956. He also received the distinction of being appointed an Honorary Doctor of Science (Engineering) of London University and Doctor of Science of Durham University.

Sir Claude had been a member of the BEAMA Council since 1944 with the exception of the years '54, '55, and '56, and had officially accepted the invitation of the Council to become the next President of the Association. His personality, wide technical knowledge, and exceptional experience of world electrical conditions will be sadly missed.



Cover illustration. *While the Illuminating Engineering Society has just completed its first 50 years, one of the leading British lighting firms—Benjamin Electric Ltd—is already into its second half-century, having been founded in 1908. Among the photometers and measuring equipment in the firm's new research laboratories completed a few years ago, is the photometric integrating sphere shown in our picture. It is 12 feet (3·65 m) in diameter, weighs 2 tons and has a perfect white inner reflecting surface.*

The Electrical Power System of the Comet 4

The British Overseas Airways Corporation's new fleet of Comet 4 jet aircraft, one of which established in record time the world's first regular transatlantic jet service on October 4, 1958, has focused world-wide attention on this latest triumph of British engineering skill and achievement. In the course of their development, the Comets have undergone probably the most stringent and exhaustive tests in the history of the British aircraft industry, and have fully justified the confidence of their makers, the de Havilland Aircraft Co Ltd.

One of the problems was the evolution of an efficient and reliable electrical power system capable of meeting the demands imposed by the size and operating conditions of the aircraft, and in this the de Havilland Co had the collaboration of the British Thomson-Houston Co Ltd, whose experience in aircraft electrical equipment began as long ago as 1913.

The following description of the finally developed system has been mainly contributed by the de Havilland and BTH companies.

At the time of its inception the Comet was an extremely advanced project. For this reason the policy was, wherever possible, to use equipment which already had an established record of performance, and to develop it to meet the new operating conditions.

The standard 28 V earth-return dc power system was the only electrical power system available to meet this requirement and the task was to develop it to give reliable operation at an altitude of 40,000 feet (12,200 m) while retaining a satisfactory power-to-weight ratio.

The two major difficulties with 28 V dc systems are the weight of cables and the operation of electrical brushgear at altitude. Fortunately, with the Comet, the four engines are all close to the fuselage and the main power cables from the engine-driven generators to the busbars are short. Similarly it was possible to use short cable runs to carry the majority of the heaviest loads.

BTH Generator Development

The brush problem did not seem to offer so easy a solution. However, a careful study of the complete electrical installation in the aircraft mock-up showed that most of the electrical components fitted with brushes could be positioned within the pressure hull, with the result that the brush problem was confined to the main generators.

Although the high-altitude operation of brushes is no easier on slip-rings than on commutators, it is possible in an aircraft alternator to keep the brush loading much lower than would be the case with a conventional dc generator; this is because the brushes are required to carry only excitation current, and not output load current. It was ultimately decided therefore to proceed with this type.

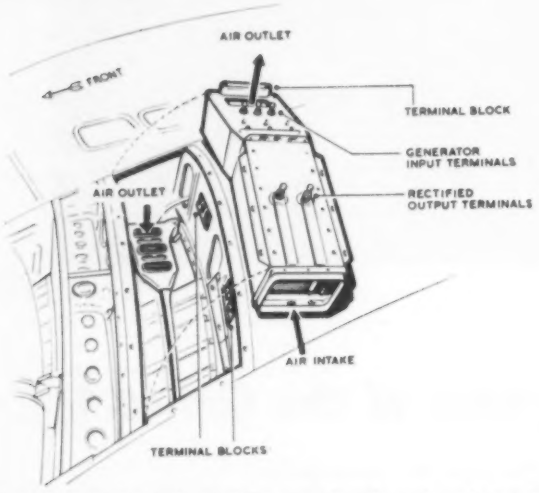
Early Comet experience soon showed that the bearing life in alternators running continuously at 10,000 rpm was as much a problem as brush life. The solution to this problem was to replace grease in the bearings with oil.

In the Comet 1, the alternator was mounted vertically so that it was a relatively simple matter to lubricate the bottom bearing with oil; it was not, however, possible to apply oil lubrication to the top bearing.

Increased power demands of the Comet 4 necessitated an entirely new design of alternator. This is mounted in a horizontal position and is coupled to the engine through a disconnect device. Both bearings are lubricated with engine oil and up to 12 gallons (56 l) an hour are fed into the hollow shaft through the bearings and out into passages in the main-frame casting back to the engine bevel gearbox, without the use of external oil pipes. Because of the high speed (10,000 rpm) it is not possible to employ any form of rubbing oil seal, and labyrinth seals developed by Rolls-Royce are adopted; these are pressurized with air taken from the fourth stage of the engine compressor and by this means leakage of oil into the mechanism is prevented.

Cooling air for the alternator is taken from the third

stage of the engine compressor. The air is fed direct into and over the slip-rings, through the rotor and stator air passages, and out to atmosphere through a short duct attached to the under-wing inside surface. It is a fundamental point that the alternator was designed not only to meet the Comet's electrical demands, but especially to suit the Avon engine installation with its directly-coupled air cooling and oil supply.



The ac control unit located on top of each engine air intake houses the main rectifier, the field silicon rectifier, and other rectifier networks supplying the differential and equalizing generator circuits

Development of the Power System

Since the Comet was first designed the basic power system has never been changed from its original concept. This consisted of four main engine-driven alternators with the output rectified to dc power. The dc outputs of the rectifiers and batteries are paralleled and are controlled by carbon-pile regulators. For the Comet 4, 3·5 kVA variable-frequency supply is available from the alternator output for de-misting and de-icing the windscreens, in addition to the 350 A dc supply.

A Comet 4 wiring diagram showing one generating channel and the interconnexions with the other generators appears opposite. It will be noted that the main busbar is split into two halves joined by a contactor and a fuse. All essential aircraft supplies can be maintained through either half.

The control circuits in the power system are all protected by fuses, but the main power circuits are protected against faults between the generator and the busbar by the individual reverse current circuit-breaker; an air fuse joins the two halves and protects the system against a busbar fault.

The reverse-current circuit-breaker design was already in existence and the adoption of this system makes it possible to rupture fault currents of 10,000 A at 70,000 feet (21,300 m)—figures in excess of those possible in the Comet 4 power system.

The circuit-breaker has an inverse time characteristic which allows it to open in approximately 12-16 millisec at maximum fault currents; it can be tripped by remote control, but can be reset only by hand.

Protection against overvoltage is afforded by the operation of the polarized relay; this opens the reverse current circuit-breaker by connecting a supply to its remote trip coil. Should the alternator reach an excessive temperature, this is indicated on the engineer's electrical panel where a switch is provided to select the disconnect to the generator drive.

The heart of the power system is the dc control unit (BTH type LKF Form B7). This incorporates three small polarized relays: the selector, overvoltage, and differential relays.

The selector relay is operated by the equalizing currents obtained from the separate current transformers provided for the purpose. If one generator is called upon to supply excessive load due to overvoltage, the relay selector operates, thereby energizing the appropriate overvoltage relay, that is to say the second of two located in the dc control unit. If the cause of selection persists and the voltage of the system is forced up, the overvoltage relay will trip at a predetermined figure and disconnect the faulty generator at the circuit-breaker. A time-delay circuit prevents nuisance tripping during voltage transients.

The third or differential relay acts in the same manner as a differential cut-out in a conventional dc power system and connects the appropriate generator to the busbar by means of the main contactor.

In addition to overvoltage protection, the system incorporates an overvoltage warning device (BTH unit LPB Form B) which causes a red warning light to illuminate on the engineer's panel when the system volts creep to 30 and above; in the unlikely event of overvoltage creep occurring over a long period the red light warns the engineer when the voltage is not high enough to operate the overvoltage relay, but is high enough to cause damage to the batteries. It also warns the flight engineer to take corrective action; this is simply a matter of trimming the volts of the offending generator before it is tripped off the busbar by the overvoltage relay.

Voltage is regulated by Newton carbon-pile regulators, two of which serve each generator channel. The main (or master) regulator is connected and operated in exactly the same way as a carbon-pile regulator in a conventional dc power system. The pilot regulator is connected across part of the coil of the master and acts so as to amplify the range and therefore the sensitivity of the master regulator; it also contains the connexions for trimming, equalizing, and voltage raising for the initial connexion of a generator to the main busbar. Field current is provided by silicon rectifiers fed directly off the alternator.

Power for equalizing is provided from transformers in the ac lines of the alternator, through a network of germanium rectifiers and resistors. The operation of the equalizing circuits is then similar to dc systems, but with the advantage that it can function at much higher voltages, free, therefore, from the troubles associated with 0·5 V or other very low-voltage equalizing systems. The equalizer system has no earth connexion so that a single earth fault in this circuit does not affect its operation.

The Control Unit

The ac control unit is blast cooled. On the ground, and at low forward speed, air enters an intake at the leading edge of the wing and is sucked through the control unit into the engine intake by the depression caused by the engine itself.

At higher forward speeds the air which enters the unit

via the leading edge passes out through a hole in the top skin because the surface depression here, in flight at speed, is greater than the depression in the intake.

Operation of the System

Operation of the system is automatic. The manually-operated circuit-breaker, once closed, need never be opened again unless a fault develops.

The layout of the flight engineer's electrical panel is shown in the photograph on the next page.

With the generator control switches in the 'normal' position, the generator will automatically be switched on to the busbar as soon as the rpm have increased sufficiently to provide a voltage approximately half a volt in excess of the busbar.

Voltage build-up is initiated by a small permanent magnet built into the rotor of the main alternator. The pilot regulator, which incorporates a voltage-raising system, ensures that an incoming generator can generate at a higher voltage than one already on the line—this arrangement is short-circuited once the generator is on the line.

With all four generators connected it is possible to check the operating conditions of any one by switching the generator control switch to the 'test' position; this isolates the main contactor coil, maintains the short-circuit on the voltage-raising circuit and breaks the differential relay circuit, completely isolating the selected generator channel from the busbar. In this way, it is possible to check, and if necessary adjust, the voltage of whichever generator and regulator combination is selected.

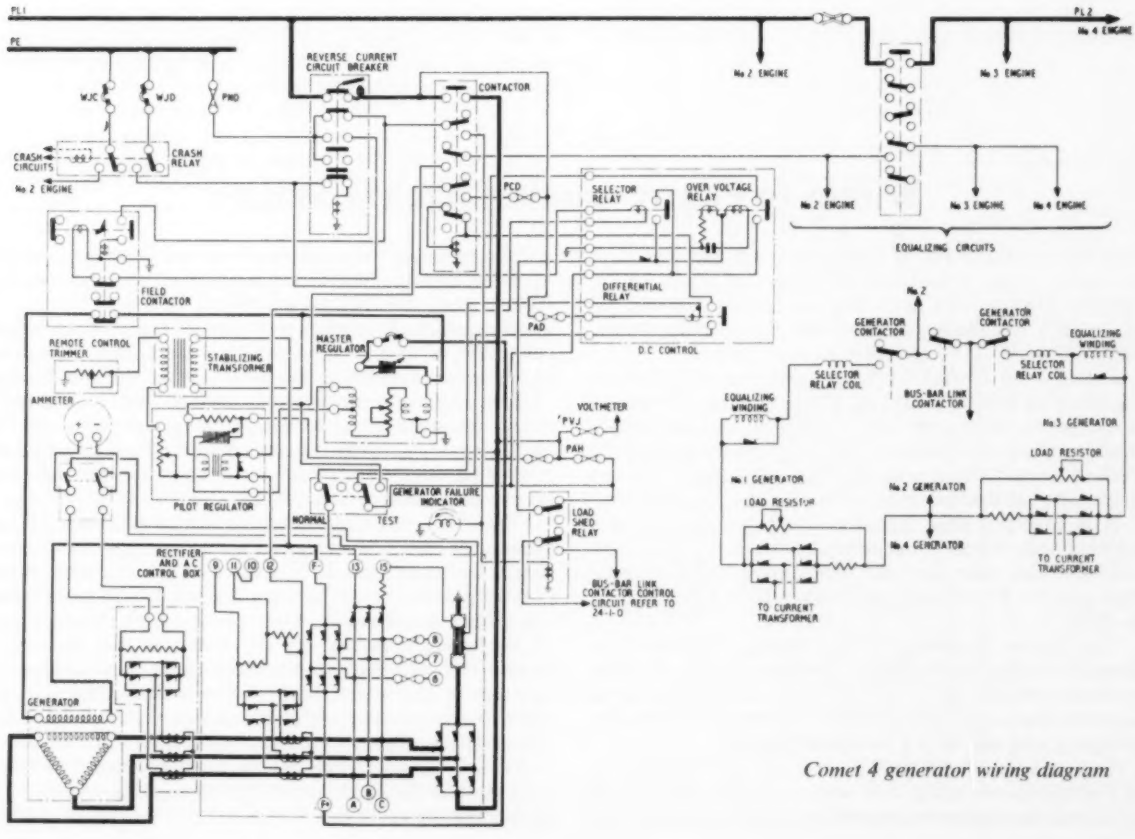
During normal shut-down, as the generator speed decreases, the voltage at the differential relay falls below that of the busbar, causing a reverse current to flow. At a predetermined value of reverse current the relay operates and opens the main contactor, disconnecting the generator. The generator warning light operates and the control switch can be set to the off position.

Power Utilization

Dc output from the system powers a variety of components ranging from small fan motors weighing 4 oz. (113 g) in the radar equipment up to the largest 4 hp motors weighing 35 lb (15·9 kg) used for driving the emergency hydraulic pumps.

Three large motor generator sets convert the dc electrical power to the 115 V three-phase 400 cps constant voltage and frequency supply required for radar, radio, and flying instruments. Power is also required for battery charging, actuators, solenoids, lighting, and domestic use.

The majority of cables of up to 35 A rating are protected by manually-set and thermally-tripped circuit-breakers (about 160 altogether) and by fuses; the former range from 6 to 35 A ratings. For switching heavy duty



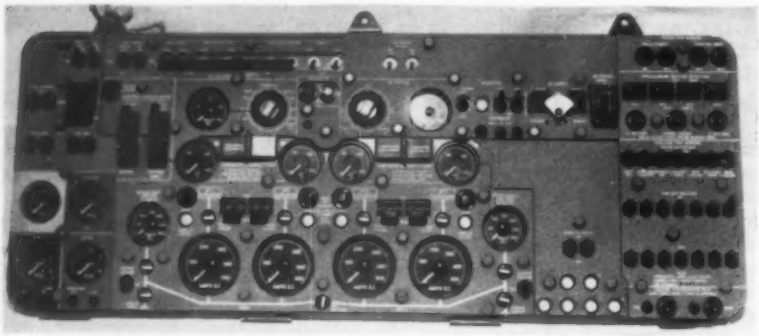
Comet 4 generator wiring diagram

circuits, over 30 contactors are used, ranging from 50 to 400 A ratings.

The electrical system described above has been extensively operated under every probable combination of electrical load and fault condition on a full-scale test rig at Hatfield. The thoroughness of the testing and high standard of trouble-free service of the Comet electrical system are apparent in daily Comet 4 operations.

Instrumentation was entrusted to Smiths Aircraft Instruments Ltd (the Aviation Division of S. Smith and Sons (England) Ltd). In the cockpit, the instrument panel incorporates Smiths flight system instruments together with the airspeed indicator, altimeter, rate of climb indicator, compass, and accelerometer. Other cockpit instruments include engine speed, pressure, and temperature indicators, and a large number of special Smiths indicators.

As the company had built up a good deal of autopilot operating experience on the earlier marks of Comet, the SEP 2 was again chosen for the latest type of this aircraft. In addition, the Comet 4 is fitted with the Smiths yaw damper—the first British civil aircraft to be so fitted.



The clear layout of the Flight Engineer's electrical control panel on the Comet 4 is apparent from this photograph. Line indication and the use of magnetic indicators make it easy to see at a glance both the layout and the actual functioning of the system

Fuel measurement, highly important on fast jet aircraft, is carried out by the Smiths-Waymouth fuel contents equipment. Smiths ice detectors are fitted as standard, as well as the navigator's periscopic sextant and a number of automatic switches which help to lighten the work of the crew.

Britain to Export Another Nuclear Station

THE Japan Atomic Power Company announced in Tokyo on April 3 that it had issued a letter of intent to the General Electric Co Ltd of England for the construction of Japan's first nuclear power station at Tokai-Mura, about 70 miles (113 km) north-east of Tokyo.

It had been known for some time that the Japanese undertaking had been making a thorough and prolonged investigation of current nuclear station designs, and it was announced in February that the company had opened exclusive negotiations with the GEC. The letter of intent marks the satisfactory conclusion of these negotiations.

It is expected that the final details of the contract, which will be worth in the neighbourhood of £20 million, will be settled later this year. The station will take about four years to build and is expected to be in full operation in 1963.

The United Kingdom Atomic Energy Authority has given the Japan Atomic Power Company a letter of intent to supply the fuel for the station and a technical assistance agreement has also been concluded between the Japanese company and the AEA's Industrial Group.

This announcement marks the successful termination of discussions extending over some two years between the GEC and the Japanese company, and was described by a GEC spokesman at a recent Press conference in London as a triumph for British engineering salesmanship in the face of keen American competition.

The new station, which will have a net electrical output of 150 MW, will be powered by a single reactor similar in its basic elements to those already being built for the British nuclear programme, but special techniques have been introduced into its design and construction which will make it virtually 'earthquake proof'. It is hoped to include a detailed preliminary description of the station in the next issue of THE BEAMA JOURNAL.

The GEC, in collaboration with Simon-Carves Ltd, is responsible for the design of the entire project. Certain items will, however, be manufactured by Japanese firms working to the British group's designs. In this connexion, the GEC has recently concluded, subject to Japanese Government approval, a long-term licensing agreement with a consortium of fourteen leading Japanese companies known as the First Atomic Power Industrial Group (FAPIG). Members of this group will also undertake the site construction work under the direct supervision of GEC and Simon-Carves engineers. In addition, the GEC will train in England a considerable number of Japanese engineers for operational work.

A New Self-Regulating Alternator with Improved Voltage-Response Characteristics

ALTERNATING CURRENT has great potential advantages for shipboard use, but one factor which has tended to retard its full development has undoubtedly been the reductions of the system voltage caused by direct on-line motor switching. This problem can be particularly serious in cases where the motors are large in relation to the total alternator capacity available—as, for example, in cargo ships in which relatively large winch loads are imposed during cargo handling, or in fact in any class of vessel in which motors required for steam raising have to be started from a relatively small stand-by generator.

While the starting current taken by a given motor can usually be reduced by installing a special low-starting-current type, it is not as a rule practicable to reduce the starting current of most motors to much less than four times the full-load current, and it is even probable that further reductions would be necessary for some of the larger motors.

Disadvantages of Conventional Expedients

Again, with the average marine auxiliary drive, the torque characteristics of the driven machinery will often permit the further reductions in starting current which can be achieved with a star/delta or an auto-transformer starter, while as a last resort a slip-ring motor with a rotor resistance starter could be used.

These expedients and special starters, and particularly the use of slip-ring motors instead of the inherently more robust and reliable squirrel-cage machines, inevitably lead to a higher first cost, increased maintenance, and reduced reliability.

In order to meet a growing demand from marine users for an alternator with superior voltage-response characteristics, the firm of W. H. Allen Sons & Co Ltd have recently developed a new self-regulating alternator which, although intended primarily for the types of marine applications previously mentioned, is equally suitable for certain land installations where its particular advantages over the conventional alternator can be most effectively utilized—such as, for example, stand-by sets in pumping stations.

This new self-regulating alternator is basically a combination of the established Allen marine-type alternator and a specially developed completely static exciting and regulating system, resulting in a transient voltage response considerably better than that of a conventional alternator and automatic voltage regulator (avr) (a voltage dip of about half and a recovery rate about twice as fast are claimed), together with the advantages of increased reliability, reduced maintenance, and greater flexibility in engine-room layout arising from the elimination of the usual dc exciter and the ability to locate the static excitation equipment in any convenient position reasonably near to the alternator.

The alternator itself is of conventional design and construction, but with special attention to those features which will assist in producing the required voltage response characteristics. The conventional shunt-wound dc exciter is, however, replaced by a static excitation system of transformers and rectifiers in which shunt and series elements are so combined as to produce inherently an alternator field current closely approximating to that required for the maintenance of normal voltage, while a static automatic trimming regulator maintains precise steady-state control to the fine limits normally associated with marine practice.

The basic principle of operation is that of phase-compensated line-current-compounding, and in addition the machine is statically self-excited, rectified ac from the machine terminals being supplied through the static excitation system to the usual single alternator field winding.

From the schematic diagram of the complete excitation and control system (Fig 1) it will be seen that the field winding of the alternator is supplied from a three-phase full-wave rectifier, the input of which is derived from the series-connected secondary windings of two three-phase transformers and is the vector sum of the two separate voltages developed in the secondary windings of the two transformers.

The output from the shunt transformers is proportional

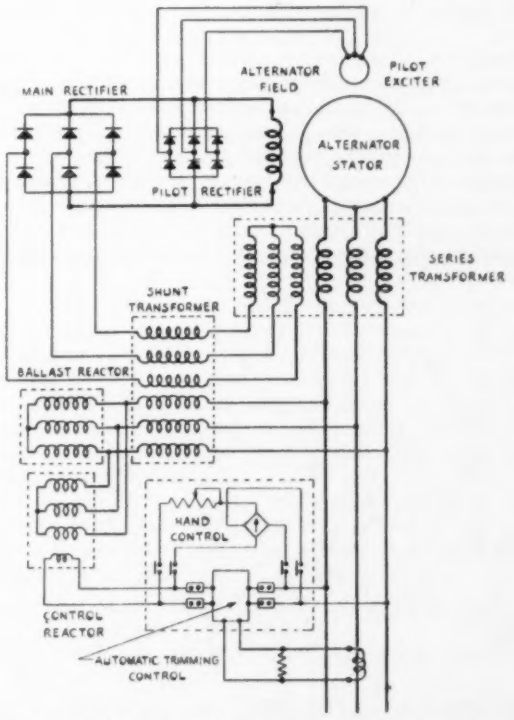


Fig 1. Schematic of the complete excitation system

to the alternator terminal voltage and directly opposite in phase, and the design is so arranged that this output voltage is sufficient to provide the 'no load' excitation component. On load, however, an additional voltage, lagging on the load current by 90°, is developed in the secondary winding of the series transformer, and it is the vector sum of these two shunt- and series-produced voltages which is applied to the alternator field winding through the rectifier. It is only by this vector combination of these two separate ac voltages before rectification that the required degree of 'phase-compensated compounding' can be obtained; that is, the required inherent excitation increases both with increases of load and reductions in power factor. By suitable coordination of alternator and excitation component design, the alternator output voltage can be maintained substantially constant over a satisfactory range of loads and power factors. The ballast reactor in the shunt circuit provides some measure of compensation for the resistance/temperature variations of the alternator field; it also assists the transient voltage response.

The use of separate shunt and series transformers makes test-bed adjustment (to suit the alternator or prime mover characteristics) particularly simple; tappings can be conveniently provided on the shunt transformer and ballast reactor, and fine control is obtainable on the ballast reactor and the series transformer by means of adjustable air-gaps in their magnetic circuits.

In practice, this simple type of inherent or 'functional' control cannot by itself provide the extreme accuracy of voltage level, irrespective of load and power factor, which is normally obtainable from a conventional alternator and avr. An automatic trimming control, in the form of a completely static regulator of the magnetic amplifier type, has therefore been introduced. The output from this regulator determines the impedance of a small saturable control reactor in parallel with the ballast reactor; relatively small changes in the drive current fed to the control winding of the saturable reactor vary the total impedance of the shunt circuit in response to any voltage changes detected by the trimming regulator, and the alternator output voltage is thus maintained within ± 2 per cent of the desired value at any load or power factor and irrespective of the normal variations of speed and temperature.

If parallel running compensation is required, a conventional 'quadrature droop' compensation signal is injected into the voltage detector circuit of the automatic trimming control. This signal is conveniently derived from an adjustable resistor in the voltage-signal side of the error-detector circuit; this forms the secondary burden of a small current transformer connected in one of the alternator lines, and the resultant voltage signal is thus modified in magnitude and phase in response to variations in the alternator output current and power factor.

Although the automatic trimming control, being completely static, is inherently robust and reliable, a manual control unit has been provided as a precaution against the possible failure of any of the components. This comprises a small auxiliary rectifier and regulator together with an 'Auto/Manual' change-over switch. With the switch in the 'Manual' position, the control winding of the saturable reactor is fed from the alternator terminals via the rectifier and regulator, and the setting of the regulator will then determine the alternator voltage level.

While the manual control will not maintain the same degree of voltage precision as the automatic trimmer, the design of the basic excitation system is such that the voltage

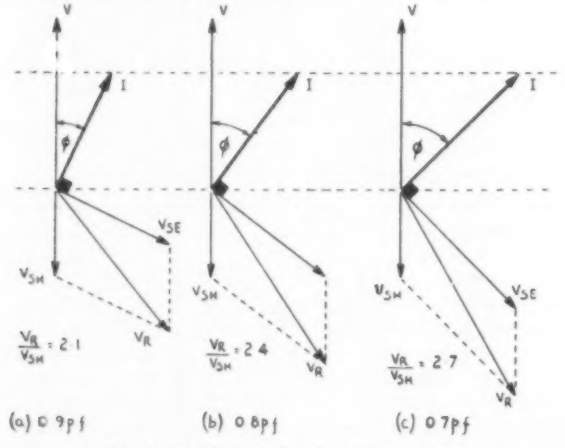


Fig 2. Excitation circuit voltage vectors

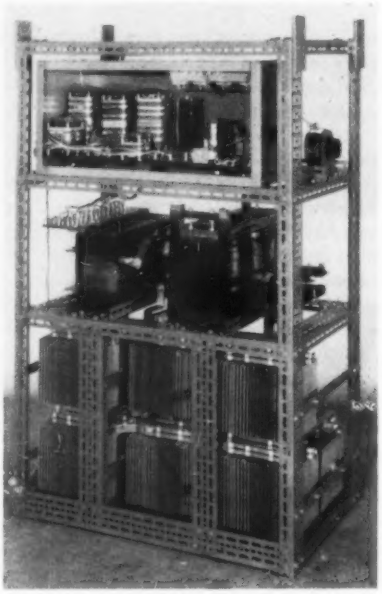


Fig 3. A prototype model of the complete equipment. The top shelf houses the control reactor on the left and the automatic trimming control on the right; on the middle shelf are the shunt transformer (left) *and the series transformer* (right)*; the bottom compartment houses the main rectifier*

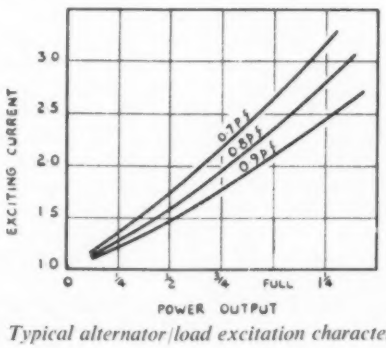


Fig 4. Typical alternator/load excitation characteristics

will remain sensibly constant over a wide range of loads and power factors, and in particular the inherently superior transient response is equally maintained with manual control operation.

Because of the very low residual voltage obtainable from many alternators, a small permanent magnet pilot exciter is incorporated to establish sufficient alternator terminal voltage to enable the main excitation circuit to become self-sustaining.

It will be seen from the circuit diagram that the ac output from the pilot exciter is rectified by a small auxiliary rectifier in parallel with the main excitation rectifier, and at normal speed this provides sufficient alternator field current to produce an open circuit terminal voltage of about half the normal value. At well below this voltage, however, the main circuit becomes self-sustaining and takes over the excitation. The blocking action of the auxiliary rectifier then prevents any current flow in either direction in the pilot exciter circuit, which runs in what is in effect an open-circuit condition during the normal operation of the alternator.

The adoption of this small permanent magnet pilot exciter (which has no commutator or brushgear, an output of only 100 or 200 W even for the largest alternators, and is in any case loaded for only a few moments during the initial excitation process) provides a system which is claimed to be completely positive and reliable; provides voltage initiation which is independent of the alternator residual voltage, and avoids the use of any form of starting relay or contactor.

With a conventional alternator and avr, the application of a heavy load such as the starting current of a squirrel-cage induction motor produces a voltage dip (due largely to the effect of the transient reactance), and the process of voltage recovery is subject to several time-delay stages, the most important of them occurring in the alternator and exciter fields. With the Allen self-regulating alternator, the initial voltage dip is considerably reduced by the almost instantaneous compounding effect of the load current exciter series element in the total excitation, and the elimination of the time-delay stages inherent in a rotary exciter and an electromechanical avr enables an exceptionally rapid voltage recovery to be made.

Some typical performance figures are shown in Fig 5, which illustrates the results obtained on a 350 kW 450 V 1800 rpm marine alternator. It will be seen that the initial voltage dip is extremely small, and that the recovery to normal voltage is a great deal faster than would be possible with a conventional alternator with a normal exciter and avr. The detailed response curves confirm the claims made earlier in this article that the voltage dip and the recovery time are both about half the normal values, and

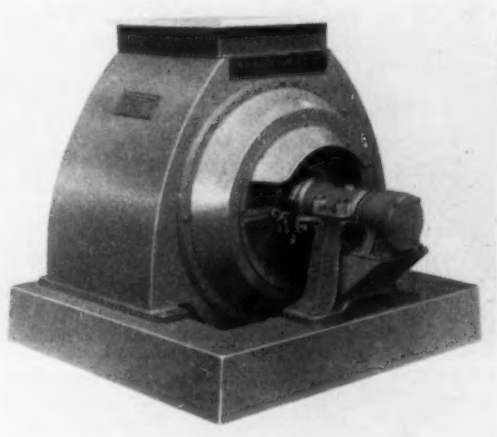


Fig 6. An impression of a complete alternator for use with the static excitation system. The small size of the permanent magnet pilot exciter is a notable feature

the makers consider that this characteristic will be completely satisfactory for most marine applications.

This equipment was recently demonstrated to the technical press, and its behaviour under various conditions of load switching was clearly shown both by meter indications and observation of check oscilloscope traces of the transient voltage response. By using a long-persistence tube, the complete trace of voltage variation from normal against time was easily observed.

As a matter of interest, both the transient and steady-state alternator loads employed for the demonstration were at zero power factor and consisted of special oil-immersed test reactors. Since in practice the important transient loads (such as the starting currents of squirrel-cage induction motors) are at power factors of about 0·2 to 0·4, these tests at zero pf constituted a slightly more onerous trial of the equipment.

The company proposes to manufacture this type of alternator in the same ranges of outputs and speeds as those of conventional alternators already in production. These are, very approximately, as follows:

Turboalternators: 200 to 1500 kW (or above if required), 50 or 60 c/s, 1500 or 1800 rpm.

Diesel alternators: 100 to 1000 kW (according to speed) at 250 to 1200 rpm, 50 or 60 c/s.

Smaller machines than the above can also be supplied if required.

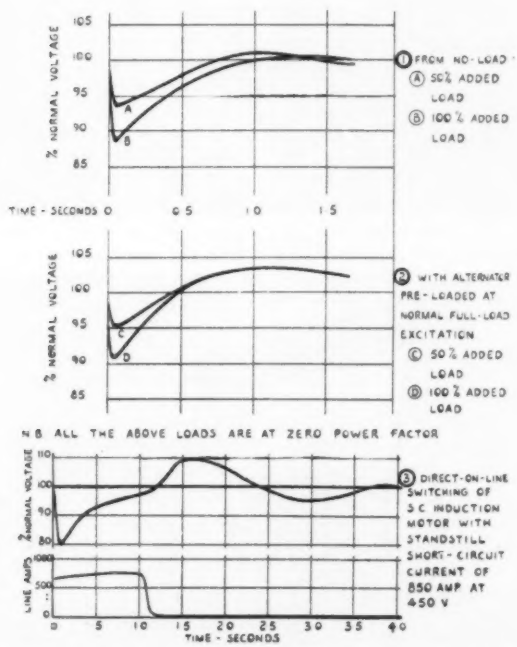


Fig 5. Voltage response oscillograms (automatic control)

(Top left) *The signing of the agreement between Britain and Euratom in February. The signatories are* (left to right) *Lord Plowden, Chairman of the UKAEA; the Rt Hon Reginald Maudling, HM Paymaster-General; the Rt Hon Selwyn Lloyd, Foreign Secretary; Professor Enrico Medi of Italy*

'Britain Leads in this Atomic Age'

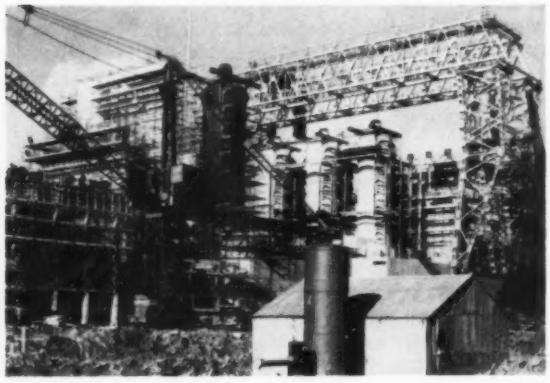
THIS is the title of a 16-page booklet distributed at the Hanover Trade Fair by the Nuclear Energy Trades' Association Conference (NETAC), who cooperated with the Board of Trade in staging the British Exhibit.

These photographs are from the booklet, which tells the story of Britain's achievements in the development and application of nuclear energy for power generation and for industrial, medical, and research purposes. Copies of the booklet, which is produced in English and German versions, are obtainable from NETAC, 32 Victoria Street, London, SW1.

(Left) *British and Italian personalities present at the laying of the foundation stone examine a model of the Latina nuclear power station now being built by a group of British firms*

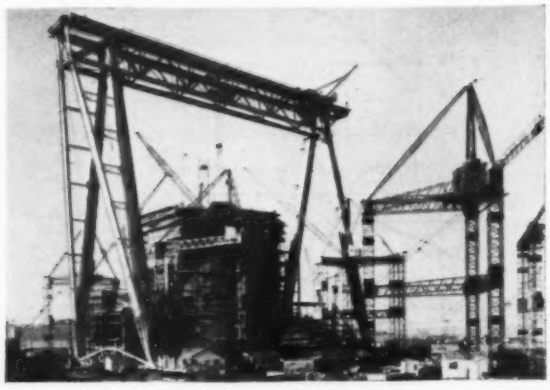
The four photographs below show the latest stages of construction of Britain's four new nuclear generating stations

Berkeley, 275 MW



Bradwell, 300 MW

Hinkley Point, 500 MW



Hunterston, 350 MW

Nuclear Research Goes Ahead

DURING the last few months, several important developments in Britain's nuclear research programme have been announced, covering the construction of new research reactors and the establishment of a new nuclear research centre. Most of these are national projects and are being undertaken by the Central Electricity Generating Board and the United Kingdom Atomic Energy Authority in conjunction with the British nuclear industry, but one is an international effort initiated by the OEEC European Nuclear Energy Agency in which Britain, five other countries, and Euratom will all participate. This is the 'Dragon' project referred to later.

The new research centre is to be established by the Central Electricity Generating Board near the nuclear generating station now being built for the Board at Berkeley, in Gloucestershire, by the AEI–John Thompson Nuclear Energy Co Ltd. The research centre, which will cost about £1 million, will be self-contained and administratively separate from the power station and will comprise engineering, physics, metallurgy, and chemistry laboratories.

Extensive Facilities at CEGB Laboratory

Some of the laboratories will enable studies to be made of intensely radioactive materials; in addition, laboratory accommodation has been incorporated for work with materials having no radioactivity but giving rise to a toxic hazard. Facilities will be available for general engineering development work connected with operating problems arising during the lifetime of the reactors. Among the kinds of work envisaged are heat transfer and fluid flow problems, some unit processes in chemical engineering, the development of complicated structures and mechanisms for the study of engineering designs and materials, and the study of stresses in massive structures.

One of the functions of the laboratory will be to give a constant appraisal of the state of materials used in the construction of the reactors by detailed examination of monitor samples removed on a programmed basis from the Board's operating reactors, so that full knowledge is gained of the components of the reactors. Work in the radioactive laboratories will be carried out on materials which have been subject to the intense irradiation present in the reactors from the production of electricity. The purpose of this work is to study the behaviour of materials during operation under such conditions and to point the direction of fundamental research and technical development.

In the physical laboratories work will be carried out on experimental programmes in nuclear and reactor physics with the aim of devising nucleonic instruments to assist in the work of the laboratories and in reactor operation.

The results of the study of irradiation effects will be of considerable scientific value to Britain's nuclear programme and to the export trade. The work of the centre will also be directed to providing design engineers with better materials for improved and advanced designs, and the operating engineers with superior reactor components —all leading to improved reactor efficiency and lower electricity production costs, and so helping to maintain Britain's lead in the generation of electricity from nuclear power.

New Reactors for Atomic Energy Authority

Looking further ahead to the second and third generation of nuclear power stations, intensive research and development work is in progress on the Advanced Gas-cooled Reactor (AGR) and the High Temperature Gas-cooled Reactor (HTGR). The latter is being studied as the reactor of the future, and the AGR can be regarded as being midway between the HTGR and the British nuclear power stations now under construction in this country and in Italy, and soon to be started in Japan.

In the AGR field, the UKAEA is already under way with an experimental advanced gas-cooled reactor at Windscale, now being expanded as one of the national centres for the development of gas-cooled reactors. This experimental reactor will have a heat output of 100 MW and a net electrical output of 30 MW and is expected to be completed during 1961.

The Authority has recently announced the construction at a cost of about £1¼ million of another reactor at Windscale—a low-power research reactor known as 'Hero', meaning Hot Experimental Reactor of 0 (zero) power. Its function will be to complement the work on the AGR by making it possible to carry out low radiation level measurements and to experiment with several alternative fuel arrangements to obtain the best results.

'Hero', which will generate only a few kW of heat, will consist initially of a graphite structure 19 feet (5·8 m) in diameter and 19 feet (5·8 m) high, but an important feature is that it will be possible to dismantle it and rebuild it in a variety of ways. The graphite core will be contained in a steel vessel connected to a pipe circuit with pumps and heaters so that it can be operated at high temperatures in carbon dioxide. It will, in fact, be the reverse of the AGR since the carbon dioxide gas will supply heat to the core instead of removing heat from it. The fuel will consist, as in the AGR, of clusters of pencil-like rods of uranium oxide sealed into beryllium cans, and these will be arranged in channels in the graphite on a regular lattice.

It is expected that from about 1965 onwards, nuclear power station reactors will be based on the AGR, using uranium oxide fuel in beryllium instead of magnesium cans. This will permit higher operating temperatures and heat ratings and will therefore lead to greater efficiencies than can be achieved with the current reactor design in the stations now building. The levels of radiation inside the AGR will be considerably higher, and this raises new problems in the fields of reactor physics and reactor materials.

The most important of the latter is to develop fuel elements which can withstand high burn-up under the exacting conditions of high temperature and high flux, and the main purpose of the AGR prototype is to test various types of fuel under full reactor conditions. For this purpose it will be run at high power for prolonged periods.

The reactor physics problems concern the behaviour of neutrons within the reactor. The high radiation levels necessary in the AGR for fuel testing and power production prevent the physicist from gaining access to the parts of the reactor which need the most careful study. One of the most important functions of 'Hero' will be to permit the use of the sensitive techniques now available to carry out the necessary measurements at low radiation levels.

In addition there are the problems of the kinetics and stability of highly rated reactors. AGR fuel is intended to remain in the reactor for a long time, building up very substantial amounts of plutonium. The reactivity of such a system depends very largely on the fuel and moderator temperatures and on the isotopic content of the fuel. The stability and control of such reactors needs very careful study.

In the HTR field, a zero energy experimental reactor —'Zenith'—is being built by the General Electric Co Ltd for the AERE at Winfrith Heath, and is expected to be completed this year. The international project 'Dragon' mentioned earlier will also involve the construction at Winfrith Heath of an experimental high temperature reactor producing several MW of power, and this will form the basis of a five-year research and investigation programme carried out jointly by Great Britain, Euratom, Austria, Denmark, Norway, Sweden, and Switzerland. This project is one of the first results of the recently concluded agreement between the British Government and Euratom.

The Eleventh British Electrical Power Convention

THE theme of this year's Convention, to be held at Torquay, Devon, from June 1 to 5, will be 'Electricity and Its Contribution to the Standard of Living'. The President of the Convention is Mr C. R. King, CBE, COMP IEE, MINSTF, Deputy Chairman of the Central Electricity Generating Board, who will deliver the Presidential Address, and the subsequent sessions will include the following papers:

'Progress on the First Nuclear Stations—Bradwell, Berkeley, Hinkley Point, and Hunterston'

Mr F. H. S. Brown, BSC, MIMECHE, MIEE, Full-time Member of the Central Electricity Generating Board, and

Mr J. Henderson, MC, BSC, ARTC, Chief Engineer, South of Scotland Electricity Board.

'Priority No 1'

Mr A. N. Irens, MSC(ENG), MIEE, Chairman of the South Western Electricity Board.

'The Scope of Installation Engineering'

Mr C. C. Hyams, MM, President of the Electrical Contractors' and Allied Associations.

'The National Inspection Council for Electrical Installation Contracting—Its Objects and Organization'

Mr E. J. Sutton, MIEE, Chief Technical Officer, National Inspection Council for Electrical Installation Contracting.

'Lighting and the Common Weal'

Mr O. W. Humphreys, CBE, BSC, MIEE, FINSTP, Director, Research Laboratories, General Electric Co Ltd.

The last session of the Convention will be an 'Electrical Forum', in which a panel of experts will give impromptu replies to electrical questions. This will be followed by the annual general meeting.

The Exhibition

The exhibition which runs concurrently with the Convention will this year cover an area of 11,600 square feet (1078 m²), with 38 firms and associations participating. Of the 30 stands showing electrical equipment, 22 will be occupied by the following BEAMA member-firms:

Aidas Electric Ltd.
H. J. Baldwin & Co Ltd.
Belling & Co Ltd.
British Insulated Callender's Cables Ltd.
Bulpitt & Sons Ltd.
Burco Ltd.
E. K. Cole, Ltd.
Dimplex Ltd.
EMI Sales & Service Ltd.
English Electric Co Ltd.
General Electric Co Ltd.
Heatrae Ltd.
W. T. Henley's Telegraph Works Co Ltd.
Hoover Ltd.
R. Maclaren & Co Ltd.
MK Electric Ltd.
Parkinson Cowan Appliances Ltd.
A. Reyrolle & Co Ltd.
Sangamo Weston Ltd.
Santon Ltd.
Siemens Edison Swan Ltd.
South Wales Switchgear Ltd.

'Escort' – A Marine Radar with Unusual Features

IN designing their new marine radar equipment 'Escort', the British Thomson-Houston Co Ltd have had two major considerations in mind. One was to overcome the limitations of previous radar equipments which required measurement and calculations (and therefore a time delay) before the information on the display could be fully interpreted; the other was to simplify the operator's task by reducing the number of controls brought out for his use.

The basic concept of the 'Escort' was, therefore, to make it much more than a passive 'look-out'; in other words, to make it interpret the situation instead of merely recording it. At the same time, steps were taken to make the handling of the set seem natural and easy.

The first objective has been achieved by the 'Chart Plan' presentation, in which four forms of display can be selected to meet different situations. With one control setting, the centre of the rotating sweep (*i.e.* the ship's own position) travels across the display in the direction of the heading marker and at a speed corresponding to the ship's own speed. This gives the display a fixed frame of reference; stationary objects appear as stationary echoes, while echoes from moving objects draw 'tails' behind them which show their aspect and true course. A repeater from a transmitting compass and a pair of contacts on an electric log (or alternatively an estimate of speed set in by hand) are required to generate the translatory movements which correct for the ship's own movement and stabilize the frame of reference of the display.

The name 'Chart Plan' has been given to this form of presentation because of its similarity to plotting on a chart, and thus its great advantage is that it gives at a glance information which could be obtained from the conventional 'relative' PPI only by timed observation and the use of tables.

An example of the 'Chart Plan' presentation showing a picture typical of a busy waterway is shown in Fig 1. This is a photograph of a display of the entrance to Southampton Water, the ocean terminal on the south coast of England, and shows a typical situation in which there may be a large number of stationary objects to identify for navigation and two or three moving ones to note for avoidance. In a 'relative' display, all the objects shown (except 'own ship') would have 'tails' contributed by 'own ship's' motion, and it would then be a matter of analysis to distinguish between the different kinds of objects and to determine the direction of motion of the moving ones. 'Chart Plan' is not provided on the 24 mile and 48 mile ranges because the rate of movement at those ranges is so small that the tails would not be long enough to give accurate information.

On the other hand, 'relative' data cannot be easily extracted from the 'Chart Plan' presentation—'closest approach distance' being an important example. In the second form of display, this facility is provided by a position of the display selector switch which stops the 'Chart Plan' shift generators at will, so that the tails of the echoes will turn and indicate their relative courses. The other positions of the selector switch provide relative displays, either 'North upwards' or 'Ship's head upwards'. The latter requires neither compass nor log and could be a useful standby in the event of breakdown.

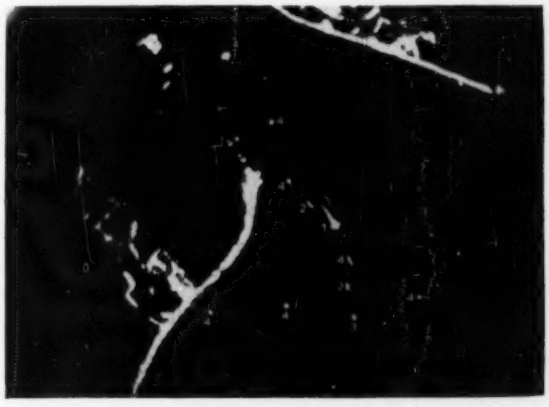


Fig 1. A typical 'Chart Plan' presentation showing (1) the ship's own position and heading, (2) other ships moving in and out of Southampton Water, (3) Calshot Spit Light, (4) buoys

The accuracy of the 'Chart Plan' computing circuits depends on the scale of the display and in general is within a few per cent.

With 'Chart Plan' presentation, the ship's own position moves across the display and must be periodically reset. It is started 'off-centre' from a point two-thirds of a radius away from the geometrical centre, moves through or close to the centre and on to a point approximately one-third of a radius beyond the centre, so that resetting is necessary at intervals which depend on the ship's speed and the scale of the display in use. For example, with a ship's speed of 12 knots on the 12 mile scale, resetting would be required every hour; or every 20 minutes at 18 knots on the 6 mile scale.

Automatic Resetting

The optimum position for resetting is a point from which the ship's heading would pass through the centre, and this will necessarily be influenced by any changes of course which might have been made since the previous reset. The optimum distance is considered to be two-thirds of a radius, and these two coordinates defining the 'Vantage Point' as used in this equipment are continuously available in the Chart Plan computer for the resetting operation, which is normally carried out automatically when a predetermined boundary line has been crossed. The automatic circuit can be delayed if an imminent reset might interfere with an observation, but it is deliberately arranged that the reset cannot be suppressed completely.

This operation is clearly shown in Fig 2. Suppose the ship has followed the course 1234. On reaching the line 'Reset 1', the display will reset automatically to position 5, where the heading will pass through the centre. If this operation appeared likely to occur at an inconvenient moment, the selector switch could be moved to

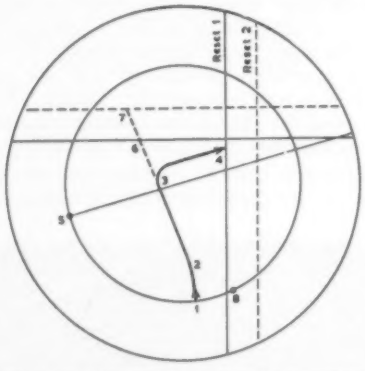


Fig 2. Diagram showing the automatic resetting feature

'Reset 2' and the display would then reset at that line. If the ship had not turned at 3 but had held a straight course, the computer would have selected an East-West threshold for resetting at 6 (or 7 if delayed) to a new 'Vantage Point' at 8. There are two other thresholds for ships heading south and west, and the appropriate one is always selected automatically.

The system also performs the resetting operation quickly—an important feature because while it is taking place the returned echoes are being smeared across the face of the tube. Resetting and finding the optimum position by manual adjustments might take one or two revolutions of the aerial and cause smudging of the whole picture, whereas the electronic reset reaches the Vantage Point before the aerial has rotated through 2°.

'Auto-Trim' Picture Alignment

This feature automatically corrects the orientation of the display for each position of the display selector switch. If, for example, the equipment is shut down, the compass repeater used in connexion with the Chart Plan presentation is left connected, and when the 'Escort' is again switched on, the heading marker is correctly orientated regardless of any changes of course in the meantime.

This is of particular importance with a 'North upwards' picture, where an incorrect alignment would not be immediately obvious as it would be with a 'Ship's head up' display. Furthermore, the 'Auto-Trim' system incorporates a means of monitoring itself, and a warning light comes on if a heading error builds up beyond a few degrees.

Electronic Bearing Marker

This device enables the bearings of echoes to be readily determined when the display is off-centred. The marker is a radial line painting once at each revolution of the aerial, and is distinguished from the heading marker by the fact that the point at which it begins to paint is the radius of the indicated range, whereas the heading marker paints from the origin. This is clearly shown by a typical configuration illustrated in Fig 3.

This type of marker is notably awkward to use, since there is no visual indication of the result of adjusting the control knob until the next revolution of the aerial paints in the new position. To lay the marker on a particular echo on the display may therefore require a number of successive attempts, each needing one revolution of the aerial to show the adjustment.

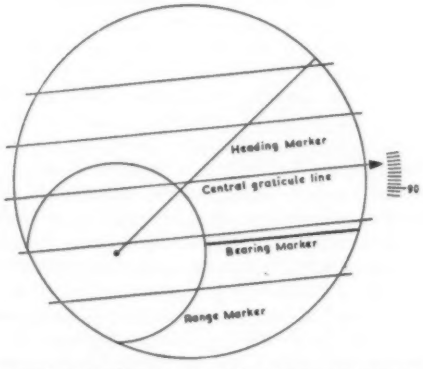


Fig 3. A typical configuration of the electronic bearing marker

In the 'Escort', this problem has been solved by controlling the direction of the bearing marker by a mechanical drive from the movable graticule in front of the CR tube, and arranging for the marker to be always parallel to the lines on the graticule regardless of its point of origin. Two advantages derive from this arrangement: the bearing marker can be correctly orientated without waiting for it to paint, and its direction can be read from the scale surrounding the display which is also used for reading the graticule orientation. This also eliminates one control and one indicator and greatly simplifies the procedure.

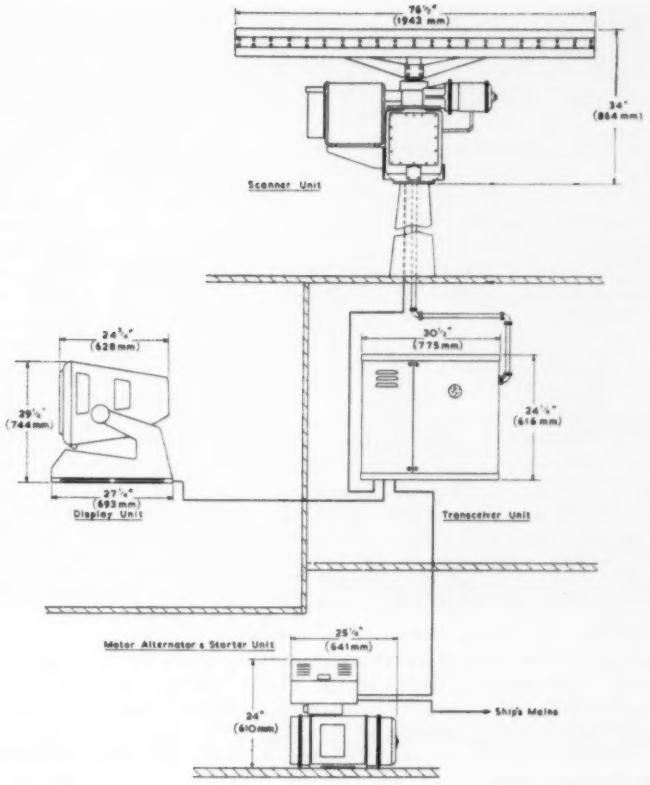


Fig 4. A schematic diagram of the layout of an 'Escort' marine radar installation showing the various units. A close-up of the display unit appears at the head of this article. The four knobs which can be seen to the right of the PPI are each of a different and clearly distinctive shape so that the operator can readily identify them by touch

Various precautions against incorrect adjustments and faults are incorporated in the equipment. In addition to illuminated warning signals to the operator, there is an echo-box performance monitor controlled by a ferrite polarization rotator in the wave-guide which confines its output to an arc of about 6° occurring astern.

Silicon junction diodes are used as recifiers in the main power packs and elsewhere in the circuits; the ht lines are protected by resettable cutouts rather than fuses in the interests of speedy diagnosis; there are two built-in meters with a switch for fault zoning, and a probe for detailed fault location.

The principal technical features are as follows:

Display System

PPI	12 in (30·5 cm.) diameter aluminized cathode ray tube
Range scales	¾, 1½, 3, 6, 12, 24, and 48 nautical miles
Range calibration rings	Rings are provided at ¼, 1, or 4 miles as appropriate
Variable range marker	Available on all ranges
Minimum range	30 yards (27·4 m)
Range accuracy	±2%
Range discrimination	30 yards (27·4 m)
Bearing accuracy	±½°

Transmitter System

Wavelength and frequency band	3·15-3·19 cm (9420-9500 Mc/s)
Peak RF power output	45 kW
Pulse length	0·12 and 0·25 microsecond
Pulse repetition rate	1200 c/s (nominal)

Aerial System

Horizontal beamwidth	1·4°
Vertical beamwidth	24°
Maximum sidelobe	– 32 db down on main beam
Scan speed	20 rpm (nominal)

Receiver System

Intermediate frequency	50 Mc/s
IF bandwidth	14 Mc/s
Noise factor	14 db
Special features	'Sea-clutter' suppression, fast-time-constant control, Manual gain control

Power-Supply System

Mains input	380/440 V 3 phase 50/60 c/s ac *or* 110 or 220 V dc
Power consumption	1·3 kW
Max. permissible mains-voltage fluctuation	±20 per cent
Voltage regulator	Automatic electronic type

IES Golden Jubilee Dinner

AMONG the many events taking place throughout this year to mark the Golden Jubilee of the Illuminating Engineering Society, the Commemoration Dinner held on February 9 at the Criterion Restaurant, London, was probably the most significant and distinguished.

Its significance was underlined by the statement printed at the head of the menu for the occasion:

> *Just fifty years ago to-night there was an informal gathering in this building of some twenty-six men of very diverse interests but all united in their desire to found a society devoted to the spread of a knowledge of the principles of good lighting.*

The dinner was distinguished by the presence of guests representing science, art, industry, the Church, national and local government, the City of London, learned societies and professional institutions, and representatives of kindred societies overseas. The after-dinner speeches were relayed to the thirteen IES centres and one of the Groups in this country, and the first two speeches were also relayed to the South African centre in Johannesburg.

Among the guests were two of the three surviving members of the twenty-six who were present at the first dinner: Lord Mount Edgcumbe and Dr R. Lessing; the third member—Professor J. T. MacGregor Morris—was unable to be present because of ill-health.

The Society's Aims

At the Commemoration Dinner the toast of 'The Illuminating Engineering Society' was proposed by the Dean of Westminster, the Very Reverend A. C. Don, who spoke appreciatively of the great strides made in recent years in the art of lighting churches. He referred particularly to the admirable results of the relighting of Gloucester Cathedral and hoped that experts from the Society would soon be called in to improve the present unsatisfactory and inartistic lighting in Westminster Abbey.

The reply was in the hands of the President of the Society, Mr C. C. Smith, who contrasted the first dinner with its company of 26 with the present gathering of 450 people, and a further 1500 joining them in spirit at the other centres in the British Isles and in South Africa.

He defined the twofold aims of the Society: to bring about a general recognition of the need for good lighting in all walks of life, and to determine by experiment and discussion what the essentials of good lighting really are. In this Jubilee Year they were concentrating on the first of these two aims; it was essential that all the people involved should get together and state their specific requirements.

The next toast—'Science'—was proposed by Dr G. B. B. M. Sutherland, Director of the National Physical Laboratory, who touched briefly on the milestones of scientific progress in lighting. Starting with Newton, who made the first fundamental discovery about the nature of light, that it is literally a mixture of all the colours of the rainbow, he recalled that it was not until some 200 years later—nearly the end of the nineteenth century—that Clerk Maxwell, Kelvin, and Holtzmann made it clear that light was a form of energy. The problem of converting electrical energy into luminous energy was first solved satisfactorily by Swan and Edison in the filament lamp. The scientific problem was to find a way of converting some cheap and easily available form of energy into luminous energy to match that coming from the sun without in fact creating a miniature sun. The modern fluorescent and discharge lamps were possibly the first steps in that direction.

The function of science, said Dr Sutherland, was to provide an infinite spectrum of light sources which the lighting engineer would have at his disposal to use in the most artistic way. But the designer of a lighting system must be able to specify his requirements, and one of the most important contributions he has made to lighting was that of providing standards that are not subjective.

He was followed by Sir Charles Wheeler, President of the Royal Academy of Arts, who proposed the toast of 'Art'—and offered the artists' congratulations to the Society for its achievements in lighting during the past fifty years. He also referred appreciatively to the Jubilee *motif*—a sun on the palm of a hand.

'British Lighting Industry Leads the World'

The toast of 'Industry' was proposed by Mr Leslie Gamage, Chairman and Managing Director of The General Electric Co Ltd and President of the BEAMA, who extolled in forthright terms the achievements of Britain and British industry. 'I can say without exaggeration that no matter what may be claimed for other British industries, the British lighting industry leads the world—that is just a plain simple fact,' he said.

Pointing out that to-day we have as much light as we want at the touch of a switch and that, whatever the job, there is a wide range of equipment for it, he emphasized that such progress does not happen on its own. We should never forget that it was in the research laboratories and factories of industry that the techniques and equipment used to-day were evolved. If industry had been content to concentrate on producing the hardware of lighting and had not shown such initiative and confidence in research, illuminating engineering as we know it would never have existed. Development work of this kind necessitated a very considerable financial outlay, and if industry was to carry out extensive research and development, then industry must be allowed to make the profits which rendered such things possible. The idea that price was the only criterion was a snare and delusion which would defeat its own object.

He concluded, as he began, on a strong note of optimism. 'We in the industry are proud of the benefits we have brought to the home,' he said. 'We are equally proud of the help we have given to all other industries. We are proud of our airport lighting and our road lighting. We are proud of our floodlighting, and you will forgive me if I have here particularly in mind the floodlighting of Niagara Falls—a technical feat which represents a new stage in this form of lighting.* But how much in all these fields yet remains to be done! What opportunities still await this great lighting industry!'

* The new colour-changing floodlighting of Niagara Falls was designed and installed by The General Electric Co Ltd [*Editor*].

The Eighth National Electrical Engineers' Exhibition

THIS year the electrical industry's largest trade show—the exhibition sponsored by the Association of Supervising Electrical Engineers (ASEE)—easily eclipsed all its previous achievements in size, number of exhibitors, technical features, and attractive appearance. Staged at Earls Court, London, from March 17 to 21, it comprised over 430 exhibitors and covered 450,000 square feet (41,800 m²).

The BEAMA is prominent among the associations supporting the exhibition, and this year over 170 stands were occupied by BEAMA member-firms—representing over three-quarters of the total area and nearly half the total of the stands devoted to electrical equipment.

The brief history of this exhibition is in itself a reflection of the rapid expansion and the energetic outlook of the electrical industry since the immediate post-war years. The first venture was a modest effort by the North-West London Branch of the Association of Supervising Electrical Engineers, who in 1950 staged a one-day show in a small hall in North-West London with 13 exhibitors. Nearly two years went by before the second exhibition was held under the title of the 'Electrical Engineers' Exhibition' with 70 exhibitors.

In 1953 the number of exhibitors had risen to 108; in 1954 there were 178, with an attendance of nearly 28,000 visitors. In the two following years the number of exhibitors rose to 240 and 310 respectively. By 1957 the exhibition was firmly established as Britain's 'shop window' for a wide range of electrical equipment, and in that year 65,000 trade buyers, including visitors from 61 overseas countries, came to see it. These figures were beaten in 1958, when the number of trade buyers was 68,000 and included visitors from 62 countries. For this year's show, nearly one million invitations were sent to trade buyers all over the world.

The exhibition effectively displays the activities of what might be broadly described as the 'middle section' of the British electrical industry; it does not include the heavy generating equipment which forms such an important part of British electrical exports, nor does it cover comprehensively the domestic appliance side of the industry, as does for example the Ideal Home Exhibition reported elsewhere in this issue. But within these limits, it is a most impressive and significant demonstration of the comprehensive range and the quality and consequent reliability of British electrical products which can be approached by very few other countries in the world.

This year the show contained many special features, of which the first to be seen by every visitor was a 40 ton 400 hp diesel-electric locomotive built by the British Thomson-Houston Co Ltd and displayed in the forecourt. One of 18 similar locomotives supplied by BTH to the order of the New Zealand Government Railways, it is of the double-ended bonnet type with a maximum tractive effort of 22,500 lb (10,200 kg), suitable for speeds up to 40 mph (64 kph) and intended for shunting and light passenger service. The next feature to greet the visitor was a spectacular lighting scheme in the entrance hall—especially appropriate, since this is the Golden Jubilee year of the Illuminating Engineering Society. An ingenious 'night sky' effect had been created by 64 fluorescent tubes reflected against a glittering ceiling pattern, while along the corridors leading into the exhibition was an 'avenue of light' produced by some 40 feet (12 m) of tungsten spotlighting recessed behind a new system of illuminated acoustic panelling. The acoustic

tiles are perforated and sections can be removed and substituted by continuous banks of illumination or by a spotlight effect. By combining special 'blue' fluorescent tubes and gas-filled lamps, the lighting can range from a soft warm glow to artificial daylight for accurate colour-matching requirements. This system, known as the Siemens Ediswan Celotex illuminated acoustic ceiling, was installed by Siemens Edison Swan Ltd.

Inside the exhibition and dominating one end of the hall was the world's largest electric clock—60 feet (18 m) in diameter. The tip of the minute hand, which measured 30 feet (9 m) from centre to tip, travelled just over 18 inches (46 cm) for each half-minute impulse received from the master clock on the maker's stand, or just over 3 feet (91 cm) for each minute.

The centre-piece of the exhibition was specially designed to mark the Golden Jubilee of the Illuminating Engineering Society and consisted of a giant hand (a stylized representation of the symbol adopted by the Society for the occasion), 18 feet (5·5 m) high and mounted 20 feet (6·1 m) above the main gangway. The hand was made in chrysteline plastic stretched over a welded steel framework and contained 120 coloured lamps operated by an automatic colour-change system. Held between the thumb and forefinger was a golden ball spouting 16 lights in a modern styling.

An Arcade of Shop Windows

On the first floor of the exhibition were other special lighting features. One of these was a very effective demonstration of shop-window lighting, a subject which is engaging the close attention of the British Lighting Council.

In an area of 5000 square feet (465 m²), a covered arcade of shops had been erected, with 160 feet (49 m) of display window frontage to demonstrate various lighting techniques. In the centre of the arcade was a bank of grass, with paved verges and two modern street-lighting columns, and at the entrance a colour and jet changing fountain installed by BTH.

The emphasis in these displays was on the correct use of lighting rather than increasing the amount of lighting, and ten lighting and fitting firms each presented one completely fitted dressed window, covering between them a variety of different kinds of merchandise and demonstrating the latest techniques of display lighting. Seven of the ten windows were presented by BEAMA member-

The photographs on this and the facing page show the seven windows in the 'Shop Window Arcade' installed by the BEAMA member-firms named at the top of page 63. The windows were designed to demonstrate different methods of applying the latest lighting techniques to the display of a wide variety of merchandise and styles of window dressing

firms: AEI Lamp & Lighting Co Ltd, Atlas Lighting Ltd, Crompton Parkinson Ltd, Falk, Stadelmann & Co Ltd, General Electric Co Ltd, Rowlands Electrical Accessories Ltd, and Siemens Edison Swan Ltd. The other three windows were by Courtney Pope (Electrical) Ltd, Harris & Sheldon (Electrical) Ltd, and Troughton & Young Ltd.

A Spectacle in Light and Sound

Adjoining this shop-window arcade was another special feature to which the name 'Aurama' has been given. This was an advanced form of the *Son et Lumière* spectacle which was originated in France a few years ago, and during the last two or three years has been further developed in this country and elsewhere into a highly spectacular and popular form of entertainment.

The principal technical development incorporated in 'Aurama' is that it is the first fully automatic electronically controlled presentation of the technique of telling a story in light and sound, the one complementing the other, and combining stereophonic music and sound effects with every possible variation of light and colour that can be achieved with modern lighting techniques.

Developed by Atlas Lighting Ltd, 'Aurama' had its première at the Exhibition. The theme chosen was a musical one—Tchaikovsky's 'Fantasy on the Tempest' —recorded by the EMI stereophonic system, and the producer decided on a stylized representation of the magic island depicted in Shakespeare's play which provided Tchaikovsky with the inspiration for his music. Constantly changing lighting effects gave visual form to the ideas and moods of the music, requiring 110 lighting cues during the 14 minutes of the performance.

The electrical equipment for 'Aurama' comprised 36 lighting circuits controlling a wide variety of light sources including orthodox stage lighting equipment and Atlas fluorescent lighting, the latter being particularly useful in providing smooth and delicate gradations of colour.

The electronic control is effected by superimposing on the magnetic tape sound track a series of signals, each of which determines a change in the visual scene. Each signal fires a pair of thyratron valves momentarily and the output of these valves during the conducting period is rectified, providing a dc signal which is distributed by stepping switches to any one or more cueing heads, each head controlling three lighting circuits.

Each lighting circuit is fed by an Atlas dimmer bank using thyratron valves. The grids of these valves are controlled by a simple phase-shift circuit, one leg of which is a capacitor and the other a photo-conductive cell, and when the light from an exciter lamp falls on the cell the valves are conducting. This exciter lamp is connected in the anode circuit of a hard valve, the grid circuit of which is itself controlled by two further photo-conductive cells, one of which determines the intensity of the exciter lamp and therefore the level of the lighting, and the other determines the time taken to reach the required level.

These two photo-cells are illuminated by a common exciter lamp. A film medium moves in steps between the cells and the lamp, and as each frame of the film moves into position a 'window' is exposed, the area of which is predetermined for each lighting change to be initiated.

Thus the whole operation is automatic and self-controlling from the moment the tape is started, and —even more important—the equipment can cope with lighting changes of a complexity and speed that would be beyond the ability of a human operator.

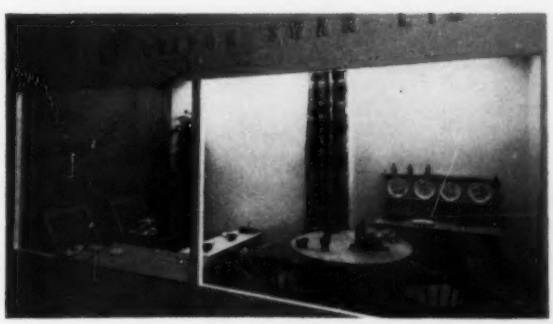
It is expected that 'Aurama' presentations may prove popular at holiday resorts, exhibitions, fairs, railway and airline terminals.

Another unusual exhibition of considerable interest was the new optic for the Eddystone Lighthouse, where it will be installed later this year, replacing the optic and rotary mechanism built by the same firm in 1882. The old optic, 12 feet (365 cm) high and 7 feet (213 cm) in diameter, is illuminated by a petroleum vapour burner and transmits a double flash of about 600,000 candle-power every 30 seconds. The new optic is only 3 feet by 3 feet (91 × 91 cm) and employs an electric lamp and lens array to transmit a double flash of equal power every 10 seconds. The beam range in good visibility is about 17 miles (27 km), but the loom will be visible beyond the horizon.

The Opening Speech

The exhibition was opened by Lord Brabazon of Tara, GBE, MC, who is President of the Royal Institution of Great Britain, Chairman of the Air Registration Board, and actively connected with the aircraft and electrical industries. Here are some of the points he made in the course of his speech.

'The application of electricity is growing daily and affecting all our lives; it grows and grows and there is no end to the fields in which it can help us, and I think the proof of that is the fact that electricity supply doubles in this country every 10 years. . . . It is, I think, interesting to speculate: had there not been a Faraday, had we not discovered, so to speak, electricity, what would the world be like to-day? It is indeed a fascinating thought—no electric light, no electric heating or cooking, no telephones



or telegraphs, no electric razors, no electric hare, no blower and no electric clock. . . .

'But two things always strike me as remarkable about the development in electricity. It is that two great things have remained static; they have been left behind in all the great advance which has taken place. I refer to the primary battery and the secondary battery. I think it is true to say that if the secondary battery had advanced *pari passu* with other developments, every motor-car in this country would have been electrically driven. . . .

'I think we can congratulate ourselves that right from the beginning we have been pioneers in this great industry. And we remain one of the leaders of the world. . . .

'There must come a saturation point in the supply of motor-cars, when all the roads are solid with vehicles and no movement takes place. Nothing like that faces the electrical industry. No saturation point is in view. The whole world is hungry for it. Confidently we go forward from strength to strength, inspired indeed by this remarkable exhibition which I have the very greatest pleasure in now declaring open.'

President of BEAMA on Exports

At the luncheon held to celebrate the opening of the exhibition, Mr Leslie Gamage, MC, MA, Chairman of The General Electric Co Ltd, and President of the BEAMA, paid a tribute to the excellence of the exhibition and then spoke about exhibitions in general. He said:

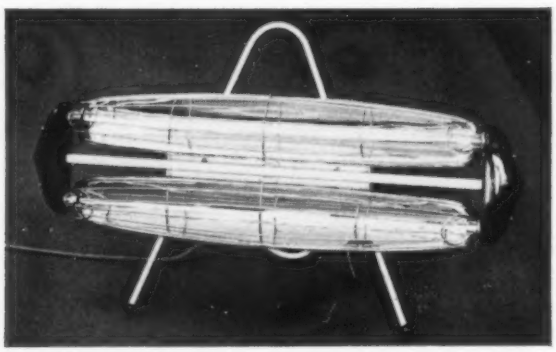
'Gone are the days when businessmen regarded exhibitions as a nuisance and a waste of money. . . . Whence comes this change in our thinking about exhibitions? Primarily it arises from an ever-growing realization of the national need for exports, and more exports, and even more exports, of which we have seen evidence quite recently in the terms we have achieved from Tokio to Tennessee.

'We welcome particularly the opportunity we have at exhibitions of discussing with overseas buyers the merits or otherwise of the products which we wish to sell. Personal contacts are the essence of successful business.

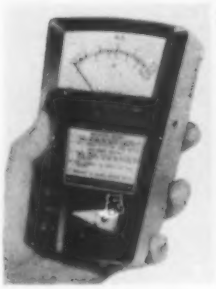
'The pessimists, of course, foresee a time when our overseas customers will be making their own goods, and will no longer want to buy our products. This presupposes manufacturers over here reaching some definite stage of development and then marking time or standing still while everyone else catches up. Personally, I am confident that British brains and British craftsmanship will not let this happen.

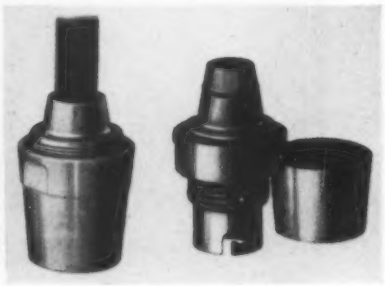
'It is not enough to be going ahead; we must see that the world knows it too. I think our exhibition arises from a rather belated acceptance of this very simple truth. Both as a manufacturer and as a citizen of this country, I feel it high time we British started to blow our own trumpet.'

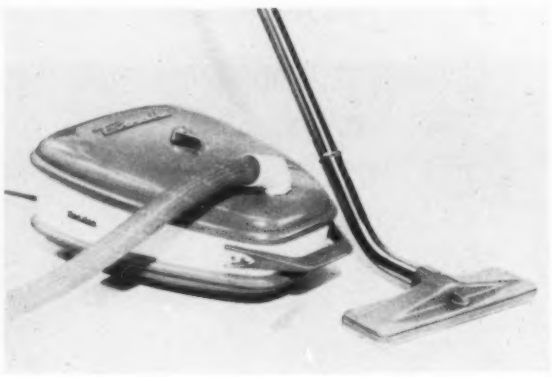
Referring to the emphasis on lighting at this year's Show, Mr Gamage said: 'We in the electrical industry have many achievements of which we are justly proud. But above all we are proud of what we have done in the lighting field, where without any kind of exaggeration we do really and truly lead the world. It is therefore justly the highlight of this exhibition.'



Winners of the annual competition for outstanding exhibits. (Above left) *Silver Trophy, Industrial Section: Flameproof dry type mining transformer*—**Brush Electrical Engineering Co Ltd.** (Above right) *Silver Trophy, Domestic Section: Portable infra-red heater*, **Dimplex Electrical Ltd.** (Below) *Highly Commended. Industrial Section: 'Metrohm' insulation and continuity tester*—**Everett, Edgcumbe & Co Ltd** (left); *Domestic Section: Contemporary style lampholders*, **Nettle Accessories Ltd** (centre); *'Tenten' suction cleaner*—**Parnall (Yate) Ltd** (right)







Notes

Scotland's First Nuclear Power

The first nuclear power station in Scotland—at Chapelcross, near Annan, Dumfriesshire—started providing electricity towards the end of February, a week ahead of schedule. The first of the four reactors went critical last November, and with the completion of the steam circuit and the turboalternator, the steam which had previously been passed to a dump condenser during the testing period was then fed to the turbine.

When all four reactors are completed, Chapelcross will have an installed capacity of 184 MW and will send out about 140 MW to the national grid. Built as a dual-purpose station by the United Kingdom Atomic Energy Authority, it will supply both electricity and plutonium.

The construction is under the control of Merz & McLellan, consulting engineers, acting as agents for the AEA's Industrial Group—the first occasion on which a private firm has been employed in this way on a major project. Among the suppliers of equipment are Babcock & Wilcox Ltd—heat exchangers; C. A. Parsons & Co Ltd—turboalternators; Stewarts & Lloyds Ltd—pipework.

Large Pumped Storage Scheme for Scotland

The first large-scale pumped storage scheme in Scotland will be one of the features of a new hydro-electric project announced by the North of Scotland Hydro-Electric Board, involving a catchment area covering 324 square miles (840 km²) and comprising one barrage, two dams, thirteen aqueducts, and three generating stations with a total installed capacity of 450 MW.

The scheme is designed to meet the growing power demand in the Scottish Highlands and from its pumped storage section it will also provide peak load supplies to the South of Scotland more cheaply than from a new steam station which would otherwise have to be provided. In return, power from the South of Scotland Electricity Board's generating stations will be used during off-peak periods to pump water to a high-level reservoir.

Three interdependent sections are planned, each contributing its quota to the whole scheme. There will be one hydro-electric generating station of 18 MW capacity; a combined pumping and generating station of 400 MW capacity to be built underground and from which water will be pumped to a reservoir at a height of 1300 ft (396 m), and a third station with an installed capacity of 30 MW which will be fed by water taken through a tunnel from a barrage on one of the rivers.

400 MW Generating Plant for Scotland

The General Electric Co Ltd has recently been awarded a contract for two 200 MW turbogenerators and auxiliary equipment to be installed at the Kincardine generating station of the South of Scotland Electricity Board. These sets are the largest so far ordered for any Scottish power station, and the value of the contract is in the region of £4 million.

The turbines will be designed for steam conditions of 2350 lb/in² (165 kg/cm²), 1050 deg F (566 deg C) with reheat of 1000 deg F (538 deg C), vacuum 28·9 in (734 mm) with 55 deg F (12·8 deg C) cooling water temperature. The feed heating will be in 7 stages to a final feed temperature of 460 deg F (238 deg C). The generators will be hydrogen cooled at a pressure of 50 lb/in² (3·5 kg/cm²) and will have an output of 235 MVA, 0·85 pf, 3-phase, 50 cycles at 16 kV. The generator rotors will have hollow conductors direct cooled by the hydrogen—the same arrangement as adopted for GEC machines already in service—with a hydrogen pressure of 30 lb/in² (2·1 kg/cm²). The stator conductors will be liquid cooled.

The contract includes condensing and feed-heating plant which will be manufactured by G. & J. Weir Ltd.

More Nuclear Power Stations Planned

The Central Electricity Generating Board is applying for consent to develop a new site of about 175 acres (71 ha) for the construction of a nuclear power station on the south-eastern bank of the Severn Estuary, 14 miles (22·5 km) north of Bristol and 4½ miles (7·2 km) downstream from the 275 MW nuclear station now in course of construction at Berkeley.

The capacity of the new station has not yet been decided, but present indications are that it will be the most powerful nuclear station yet planned; it may have a total output of about 1000 MW and feed direct to the 275 kV supergrid.

Advantage will be taken of the rock formation for the construction of an artificial tidal reservoir which will provide during low-tide periods the very large quantities of cooling water required. This unusual arrangement will reduce the capital costs which would be incurred in obtaining cooling water by normal means in an estuary with such a wide tidal range as the Severn.

In addition to this site, the Board is continuing to investigate three other areas on the Severn Estuary to determine whether they are suitable for future nuclear power development.

Other sites also under review by the CEGB for proposed nuclear stations are on the Selsey Peninsula on the south coast of England, in the Isle of Wight, and areas on the coast of Anglesey in North Wales.

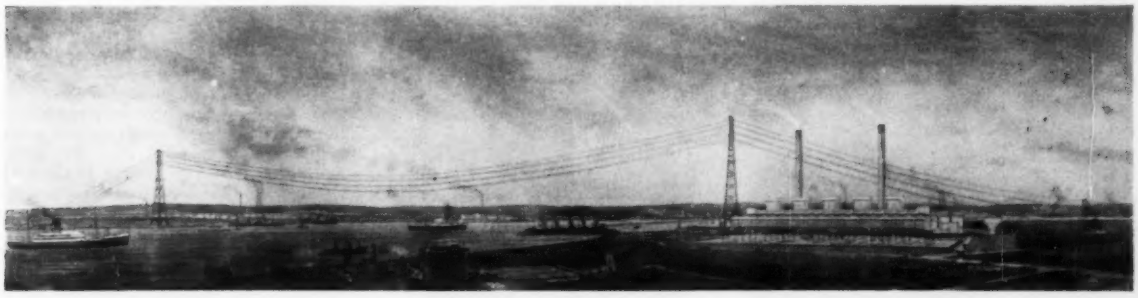
Application has also been made for consent to build two other new stations—each of a projected capacity of 650 MW—at Sizewell in Suffolk and at Dungeness on the Kent coast. The latter station will be near the English terminal of the projected cross-Channel power cable designed to link the British and French grid systems.

Aircraft Equipment by English Electric

Many types of military and civil aircraft are now using electrical equipment made by the Aircraft Equipment Division of the English Electric Co Ltd, and the design and production of such equipment now forms a major part of the English Electric Group's aviation activities. During the past four years, the work of the Aircraft Equipment Division at Bradford, Yorkshire, has increased fourfold.

English Electric equipment is incorporated in seventeen types of aircraft, ranging from complete electrical generating systems in the Victor Mk 11 and Vulcan Mk 11, the Canberra, Lightning, Jet Provost, the Bristol 192 helicopter and the Javelin, to other equipment including large and small actuators and geared motors in the Comet 4, Scimitar, Britannia, Canadair, CL 44, NA 39, Gannet, Dart Herald, and Firefly. Specialized equipment is also used on a number of British guided weapons.

The Division has also been developing a



An artist's impression of the projected second overhead line crossing of the River Thames for the British super-grid. The suspension towers, 630 feet (192 m) high, will be the tallest in Britain. The span between them will be 4500 feet (1370 m). The crossing will have two 3-phase circuits and a single earth wire; the conductors, which will be manufactured by British Insulated Callender's Cables Ltd, will each have 108 strands of 0·15 inch (3·8 mm) diameter aluminium wire over a core of 91 strands of 0·123 inch (3·12 mm) diameter steel wire, and will each carry 1550 A continuously. The crossing is designed for a working voltage of 380 kV but will operate initially at 275 kV

complete electrical system, using the Sundstrand type of constant speed drive (produced under licence by English Electric) and incorporating the first brushless alternator for aircraft designed and built in this country. This system, which is intended for the home and overseas markets, will be running in the laboratories this summer.

The military version of the Sundstrand drive is now being supplied by English Electric for the Victor Mk 11 and the Vulcan Mk 11 jet bombers and has completed 12,000 hours running, including flight testing. Production of a civil version of the drive is now starting. The new brushless alternator has already successfully completed more than 1500 hours of development running.

For the future the Aircraft Equipment Division is developing new machines and control equipment to satisfy the demands made by the performance of such new aircraft as the TSR 2 and the projected British supersonic airliner. Much attention is being given to the production of brushless generators of advanced design which will give superior service to those now available and, in particular, will not suffer from the high rates of wear at high altitude which now afflicts all types of machines using carbon brushes.

They Won't Wear Out!

The inherent quality and reliability which have always distinguished British electrical equipment have gained a world-wide reputation. Several interesting examples which fully justify this claim have recently come to light.

A Birmingham company has handed to Siemens Edison Swan Ltd a 60 W Britannia lamp which it purchased thirty years ago. The lamp was still in perfect working order.

Two British Thomson-Houston motors have been in continuous service since they were installed in 1913 in a Yorkshire brewery. They have operated under somewhat dusty conditions for six hours a day, six days a week since they were installed, and the firm reports that there seems no reason why they should not continue to give satisfactory service for many more years to come. The motors are shunt-wound dc machines rated at 31 hp 460 V, and the only attention they have ever required has been the skimming of commutators, and this has been done only twice on one motor and three times on the other.

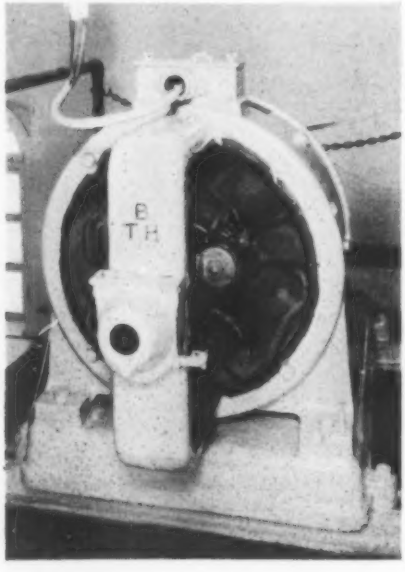
Next, a curious moving-coil instrument, made in 1883 by R. E. Crompton & Co. (now Crompton Parkinson Ltd) was recently 'discovered' by a London firm when they moved out of their old premises. The instrument is in remarkably good condition and has an interesting feature in that the hand-engraved scales are denoted 'Current' and 'Potential' but the terminal posts are marked 'Amperes' and 'Volts'. Since the International Electrical Congress did not regularize these latter terms until its first meeting in 1881, it appears likely that this was one of the first measuring instruments to use the new nomenclature.

No control springs are fitted, the earth's magnetic field being used to provide a restoring torque. As the instrument was intended for horizontal operation it would have to be lined up due north-south before functioning: all nineteenth-century switchboards incorporating instruments with similar movements must therefore have been aligned due east-west!

Finally, the Chairman of the Midlands Electricity Board recently presented to the Birmingham Museum of Science and Industry a veteran dc motor built in 1900 by Crompton & Co (since amalgamated with the Crompton Parkinson organization).

Until recently, this 2 hp 1200 rpm motor was used for the line shaft drives of printing presses, and according to a director of the printing firm had given sixty years of trouble-free service.

The old motor was still working when MEB engineers, in the course of the dc/ac change-over scheme in Birmingham city centre, were obliged to remove it. As a point of interest, it took four men to lift out the old motor, but only one man was needed to handle the modern replacement.



A New BEAMA Publication

An enlarged and revised edition of the BEAMA booklet *Abbreviations of Associations, Institutions, Research and Trade Associations* has recently been published. The first edition was issued in 1957.

The old BTH motor and the Crompton switchboard meter referred to above

In selecting the list for inclusion in the booklet from the many thousands of abbreviations now in general use, the choice was based on those most likely to be encountered by people in the electrical and allied industries. Even so, this edition covers 210 British associations, institutions, research and trade associations, 101 professional qualifications, and 78 international and overseas organizations.

The booklet is published primarily for members of the BEAMA, but copies are available for any interested organizations or individuals at the foreign exchange equivalent of 1s 6d for single copies, £1 for 20 or £4 for 100 copies.

New High Power Radio Transmitters

The first stage of an extensive expansion and modernization programme for the Overseas Telecommunications Radio Service has recently been completed. Standard Telephones and Cables Ltd, on behalf of the General Post Office, has installed at the Ongar radio station the first seven of the 23 DS13D transmitters ordered by the GPO for its current programme. These seven transmitters will operate to such places as New Delhi, Colombo, Singapore, Bahrein, and Bombay. Four more transmitters will shortly be in operation at Dorchester and the remaining twelve are now being installed at Rugby.

The design of the DS13D transmitter has many special features based on STC's wide experience in the design and building of equipment for this type of service. Linear RF amplifiers make the sets suitable for multi-channel telephone and telegraph operation, and one transmitter can handle both telephony and multi-channel telegraphs, or as many as four telephone channels simultaneously.

All functional controls, including frequency changing, are carried out by remote control, less than 30 seconds being needed to change from one operational frequency to another.

The high-power valves are air-blast cooled and the hot air can be recirculated to heat the buildings.

Wakefield-Dick's New Laboratories

C. C. Wakefield & Co Ltd have recently announced the opening of a large extension to their Wakefield-Dick's laboratories at Hayes, Middlesex, where the volume of research and development work has increased by 300 per cent during the past ten years. Some of the most modern apparatus has been installed for further research on lubricating oils and allied products.

In the new Spectrographic Laboratory the new equipment includes apparatus which analyses, spectrographically, the metallic constituents of an oil sample. In the Radio-Chemical Laboratory the introduction of radioactive isotopes will aid other aspects of research.

Facilities for routine laboratory work have been extended and each chemist is provided with separate compressed air, gas, vacuum, and nitrogen supply points.

The Wakefield Castrol Group expect that these new extensions will appreciably increase the efficiency of their research department, and so benefit the users of their products throughout the world.

A High-Voltage Cable-testing Laboratory

WHEN British Insulated Callender's Cables Limited decided to rebuild their Power Cable Works at Erith, Kent, an essential part of the plan was the installation of a large new high-voltage laboratory designed to cater for development testing of cables for operation at the highest voltages envisaged in the future. This laboratory is now in commission and its chief features are described in the following notes.

The opportunity was taken of installing in the new laboratory the latest available equipment for development work and proving tests on power cables for operation at 400 kV and above.

The main feature of the new equipment is a 3200 kV two-column Ferranti impulse generator having 16 stages of 0·28 microfarad per stage rated at a voltage of 200 kV, giving a total stored energy of 89·6 kW-secs from a generator capacity of 0·0175 microfarad.

Provision for Future Development

Owing to the continual development of power cable techniques, provision has been made to double the capacity and hence the stored energy of the generator should the occasion arise. The generator is charged via a moving-coil voltage regulator and oil-immersed rectifier set, and is provided with automatic tripping, a capacity potential divider, ultra-violet ray gap stabilization, and remote polarity change-over switchgear.

In process of completion is a 1280 kV impulse generator made by BICC which will consist of 8 stages, 0·32 microfarad per stage, rated at a charging voltage of 160 kV, and which will deliver a total stored energy of 32·8 kW-secs from a generator capacity of 0·04 microfarad. The generator is provided with remote polarity change-over switchgear and a resistive potential divider.

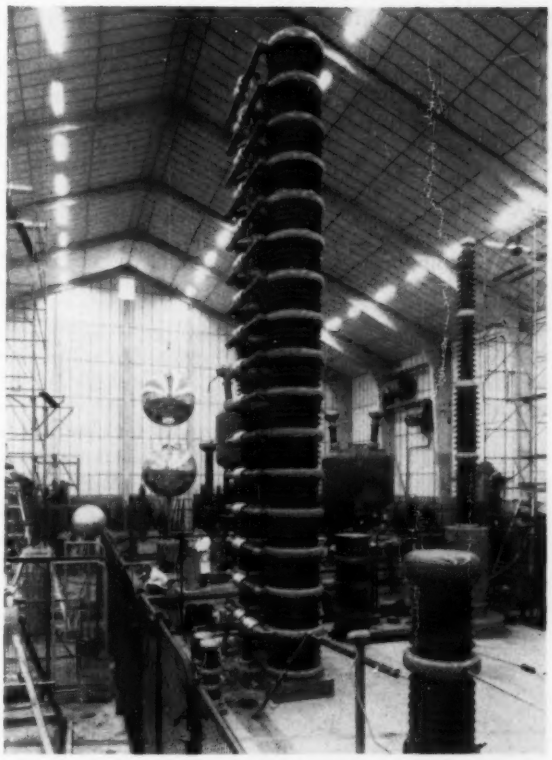
Oscillograph recordings from both generators are taken on transient recorders built to a BICC specification and provided with means of automatic programmed control.

Another major piece of equipment is an 800 kV ac testing set consisting of two 400 kV transformers, capable of cascade or parallel operation and continuously rated at 2 MVA either 400 or 800 kV, with an overload factor of 1·75 for periods of up to one half-hour. The transformers operate with live tanks which stand on insulated supports, the midpoint of each 400 kV winding being connected to its own tank.

The transformers operate in a state of controlled series resonance, giving extremely wide stable test parameters coupled with good wave form and falling current at breakdown.

The tuning reactors are situated in the main transformer tanks and are driven through an insulated shaft which couples to a driving and remote indication unit in a small pit under the transformers. The exciting source for the resonant circuit is in the form of two 42 kV feed transformers continuously rated at 100 kVA each.

The tuning of the transformers and regulation of the output voltage are so electrically coupled that the two units are kept in step when connected either in series or in parallel. Provision is made to keep the output voltage of the sets constant and to hold the transformers and load capacity in resonance by electronic means. Electronic circuits operating from a voltage source derived from capacity dividers, rather than from the usual current source, are provided for fault detection. This method has been used because the current in the transformer winding falls, as opposed to the usual rising characteristic, when the sample under test breaks down. The series resonance circuit maintains the supply power factor near to unity, with a consequent reduction in the supply demand.



The two-column 3200 kV impulse generator, with the 2-metre sphere gap in the background

The layout of the two transformers in relation to the building is such that a third transformer can be added at a later date to extend the testing voltage to 1200 kV at 3 MVA continuous rating.

Also installed in the laboratory are two 200 kV 400 kVA transformer test sets formerly used at BICC's Prescot laboratory. These transformers are fed from regulators with reactor backing and operate in the parallel mode of resonance. Their control and measurement equipment has been modified and brought up to modern standards.

In the three-phase test set, three 76 kV 50 kVA transformers are connected in a star bank and will give a 132 kV 150 kVA three-phase supply. The instrumentation and control of this set follow conventional practice.

Very-high voltage measurements can be made using a 2-metre sphere gap which is provided with remote control and indication from the control room. Mobile 25 and 75 cm sphere gaps are provided for measurement of voltages not requiring the use of the 2-metre sphere gap.

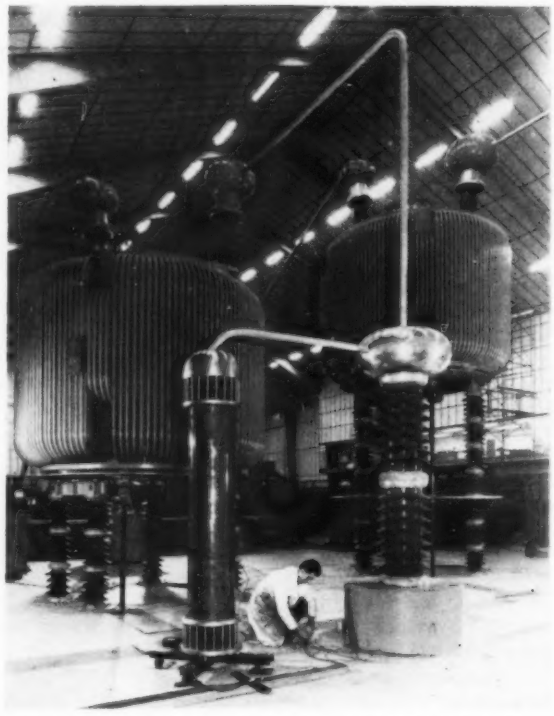
The electricity supply to the laboratory is taken at 6·6 kV through oil circuit-breakers to a 750 kVA 6600/433 V oil-cooled transformer. Local distribution of supplies is taken through fused isolator panels to individual electrical loads. A ring main is provided to give services of 415 V 60 A three-phase neutral and earth, and 3×230 V 13 A at 15 points around the laboratory. The main purpose of the 60 A service is for the operation of ring-type current-loading transformers and portable oil degasification plant; the lower current services are for small portable tools and similar appliances.

The switchgear and supply transformers were manufactured by the Brush Electrical Engineering Co Ltd, and the Brentford Transformer Co Ltd supplied the regulators for the 200 kV transformers.

The size of the equipment and the need for observation of high-voltage clearances preclude the use of cranes within the laboratory, and all lifting is done from a standardized form of crane scaffolding and lifting beams which are readily erected when required. This gives the laboratory an unobstructed floor area of 22,000 square feet (2044 m²) —as large as that of any high-voltage laboratory in the world.

The reinforcing steel over the whole floor is electrically welded to provide a ground plane which is used as an electrical measurement reference, and it is tied to nine earthing points driven into the ground to a depth of approximately 30 feet (9 m). A separate earthing system is used for earthing all the electrical supplies and the frames of the supply equipment. On one side of the laboratory are a number of cable entries which allow cables to be run out and buried in an adjacent field to simulate working conditions.

Tap setting on the 3200 kV impulse generator



The two 400 kV transformers forming the 800 kV ac test set, with capacitor stack for control and voltage measurements and standard condenser for power factor measurement

A flexible test enclosure system allows at least seven tests to be carried out simultaneously. The enclosures can be quickly erected with standard fencing sections and posts in sockets set in the floor on a 10 foot (3 m) grid. Each section includes full safety interlock facilities and danger lights. Because of the need for observing corona under conditions of darkness, the building has no external windows; twin 80 W fluorescent lighting units in four rows give an illumination level of 10/12 lumens.

BICC claim that these new laboratories are among the best equipped in the world, and the facilities for research which they afford will enable them to produce power cables to meet any contingency in the foreseeable future.

Diesel-electric Locomotives for Export

NEW 'GENERAL PURPOSE' DESIGN FOR OVERSEAS REQUIREMENTS

THE prototype of a new design of 1100 hp mixed traffic diesel-electric locomotive—appropriately named the 'Explorer'—was recently demonstrated by the British Thomson-Houston Co Ltd. The intention behind the design has been to produce a 'general purpose' locomotive particularly suited to overseas requirements and which could be bought 'off the shelf', as it were. In the past, British locomotives have usually been built to special requirements and therefore could not compete so effectively in price against the American all-purpose locomotive. It is hoped that the 'Explorer' will win orders in overseas markets by reason of its reliability, its price —which is of the order of £60,000—and the fact that when it goes into production there will be early delivery.

The locomotive has been designed for use on the lighter type of railways overseas, particularly in Commonwealth countries and South America, where freight forms a large proportion of the total traffic and where freight trains are generally operated at medium speeds. The small number of passenger trains are slow compared with European standards, generally because of the limitations of the track. Many of these railways have a track gauge of less than the standard 4 ft 8½ in (143·5 cm), and they are all restricted to light axle loads.

These requirements have been kept in mind in designing the 'Explorer', as well as the fact that it will have to operate in tropical climates and in some cases at high altitudes. By keeping the maximum engine output to 1100 hp, it will be possible to maintain the output at sea level when operating in an ambient temperature of 120 deg F (49 deg C) or up to an altitude of 4000 ft (1219 m) at an ambient temperature of 80 to 85 deg F (26·7 to 29·4 deg C).

In these conditions, the locomotive will be suitable for both passenger and freight traffic on main and branch lines, and in multiple-unit working it will deal with the heaviest trains.

The locomotive is a joint BTH–Lister Blackstone development, designed around the Lister Blackstone type ERS 12-T four-stroke exhaust turbo charged rail tractor diesel engine with a continuous rating of 1100 bhp at 800 rpm.

The two lines of six cylinders are axially parallel and opposite to each other, with two crankshafts carried in bearings supported on a common bedplate. The crankshafts are identical and are each fitted with a small flywheel. The drive is taken through hardened and ground spur gearwheels to a pinion mounted on the generator shaft which rotates at 1320 rpm, corresponding to the engine speed of 800 rpm. If it should be necessary as an emergency measure, it is possible to uncouple one bank of cylinders from the drive and operate the locomotive at reduced power on the remaining bank.

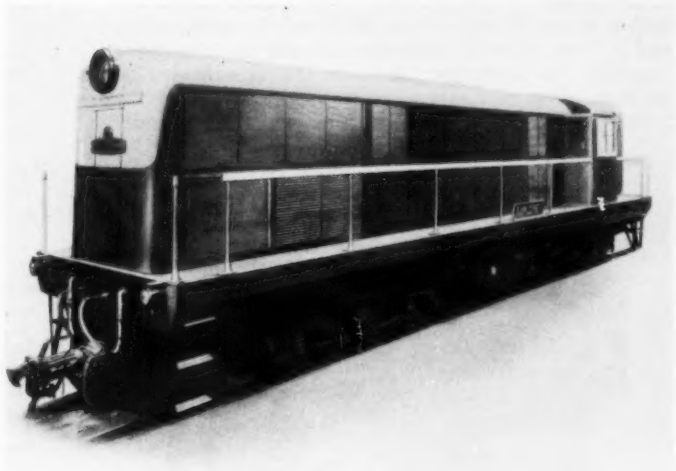
The main generator is a 10-pole machine specially designed for the severe duties associated with traction work in conjunction with an internal combustion engine. Its continuous ratings to BS 173: 1941 temperature rises with Class B insulation are

515 V, 1310 A, 675 kW, 1125 rpm
290 V, 2310 A, 670 kW, 1125 rpm.

The auxiliary generator is built on the same shaft as the traction generator and follows the same general mechanical construction. It is an 8-pole shunt-wound machine suitable for working in conjunction with the automatic voltage regulator. Its continuous rating to the same specification as the main generator is

110 V, 48 kW, 700/1125 rpm.

The differential exciter is mounted on the auxiliary generator and driven by V-belts from a pulley on an extension of the traction generator shaft. It is a 4-pole machine with self-exciting and separate field windings, and a differential winding carrying the main traction current. The exciter operates in conjunction with the load control units to regulate the load on the diesel engine.



General view of the 'Explorer' diesel-electric locomotive

The traction motors are of the box-frame type and are arranged for axle suspension with a single reduction drive to the axle. Their continuous rating is 290 V, 385 A, 440 rpm. The motor pinions drive the axles through resilient spur gearwheels, the gear ratio being 13 : 66.

The auxiliary equipment includes 2 motor-driven centrifugal blowers supplying cooling air to the traction

motors, and 2 compressors mounted at the free end of the engine and each directly coupled by a shaft extension to one of the engine crankshafts. They operate at a normal pressure of 100 lb/in² (7 kg/cm²) and are connected to a common main reservoir.

When vacuum-braked trains are to be handled, 2 electrically driven exhausters are installed. Each is of 60 ft³/min (1·7 m³/min) displacement at normal speed, and double this displacement when required to release the brakes.

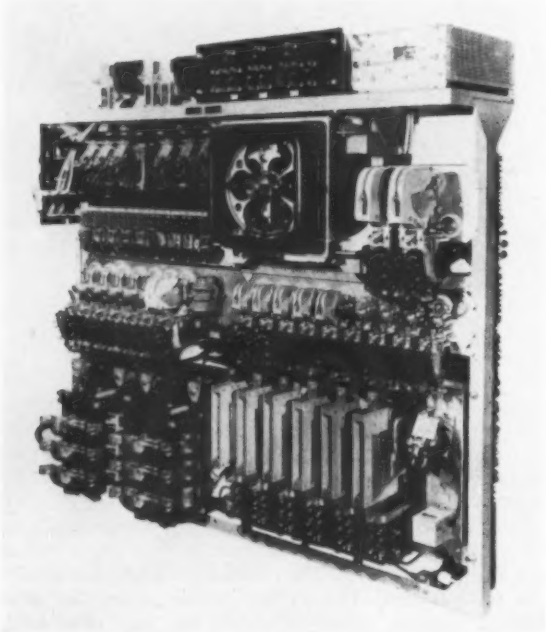
A 48-cell lead-acid battery of 144 Ah capacity is provided for engine starting and auxiliary purposes.

Constructional Details

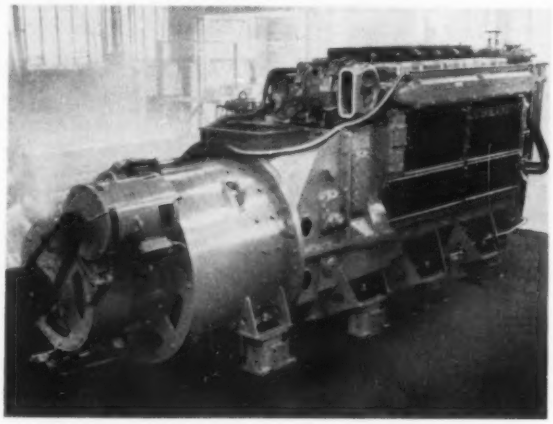
The locomotive underframe is constructed from standard sections and plates to give ample strength for the normal load imposed by service conditions and when lifting. The bogies are built up from rolled steel sections and plates welded into sub-assemblies which are riveted together to form a sturdy frame of ample strength. Each bogie has 2 rubber cone pivots of the well-known 'Alsthom' type on which the body is carried. The pivots themselves are supported on the fixed bolsters on pads of rubber which allow side movement in shear. In addition, the inner pivot assembly on each bogie can slide as a unit on manganese pads to allow the negotiation of tight curves.

The Westinghouse brake system includes a straight air brake for use when running light or when hauling unbraked stock. A vacuum-controlled straight air-brake system is used when running with vacuum braked trains and in these cases the exhausters already mentioned are installed. An automatic air-brake system can also be provided when necessary.

Electrodynamic braking, operating quite independently of the mechanical brakes, is achieved by causing the traction motors to act as generators, the current thus generated being dissipated in resistor banks. The braking effort is varied by adjustment of the field motor strength.



The equipment in the control cubicle



A view of the diesel engine showing the BTH main generator, overhung auxiliary generator, and V-belt driven exciter

The principal technical data of the 'Explorer' are as follows:

Ratings	
Engine output	1100 hp at 800 rpm
Input to generator for traction (average)	1030 hp
Tractive effort (max)	42,000 lb (19,000 kg)
Tractive effort at continuous rating of motors	24,600 lb (10,880 kg)
Maximum service speed	55 mph (88·5 kmph)
Weight	
Total weight of locomotive	minimum 72 tons
Axle load	minimum 12 tons (can be increased to 14 tons if required)
Leading Dimensions	
Minimum gauge	39⅜ ins (100 cm)
Maximum gauge	5 ft 6 ins (168 cm)
Maximum length over headstocks	49 ft (15 m)
Maximum overall height	12 ft 9 ins (389 cm)*
Maximum width	9 ft 9 ins (297 cm)*
Bogie wheelbase	12 ft (366 cm)
Total wheelbase	36 ft (11 m)
Bogie pivot centres	30 ft (9·14 m)
Wheel diameter	36½ ins (92·7 cm)
Clearance between motor and rail	6¼ ins (15·9 cm)
Clearance between gearcase and rail	5¼ ins (13·3 cm)
Minimum radius of curve	300 ft (91·4 m)
Capacities	
Fuel	500 gallons (2273 l)
Water	50 gallons (227·3 l)
Sand	20 cu ft (0·56 cu m)

As soon as the running trials now in progress in this country are completed, the 'Explorer' will be shipped to East Africa where, with the cooperation of the East African Railways, it will be given extensive proving tests on one of the most difficult branch lines near Nairobi. It will then be offered for sale.

* In certain cases these dimensions can be reduced if essential.

High-Speed Co-axial Gear Units

*R. Gardiner**

THE higher primary speeds now coming into more common use since the commercialization of the gas turbine have thrown down a challenge that gear unit builders in this country have not been slow to accept.

To keep peripheral velocities down to reasonable figures while achieving the higher ratios involved, several types of units have been developed with high and low speed shafts in line and the load distributed by the use of multiple layshafts. These units are sometimes loosely described as epicyclic, on account of the use of sun and planet pinions, but actually certain of these are not epicyclic but merely double reduction units with three layshafts.

To rationalize the position, David Brown Industries Ltd have classified this type of drive under three headings with the symbols 'SC', 'SA', and 'HC'. These are not merely identification characters but part of a studied nomenclature which gives a direct reference to the particular unit under consideration.

The 'SC' means that the unit has a high-speed Sun pinion and a low-speed Carrier. This arrangement is shown in the diagrammatic isometric in Fig 1 where it has been stripped of case, thrust cones, and all detail.

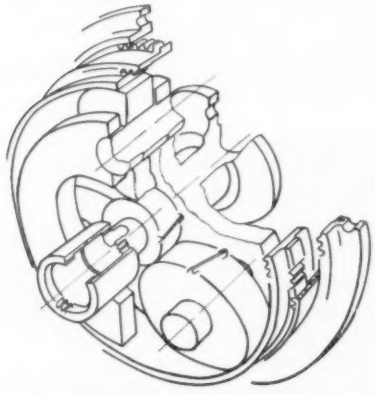


Fig 1. Skeleton isometric diagram of 'SC' type epicyclic unit

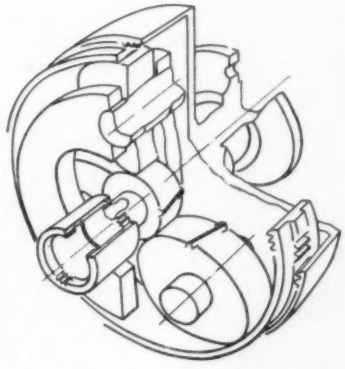


Fig 2. Isometric showing kinematics of 'SA' type epicyclic unit

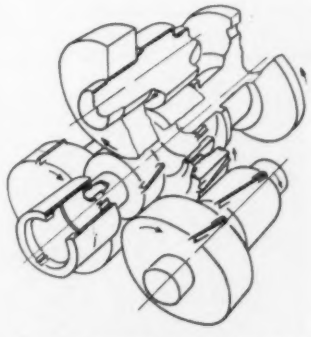


Fig 3. Schematic arrangement of 'HC' double reduction unit

'SA' means that the unit also has a high-speed Sun pinion and a low-speed Annulus as shown isometrically in Fig 2.

The 'HC' unit is entirely different in character, having no annulus and being a three layshaft double reduction unit. Hence the symbol 'HC' means that the shafts are Horizontal and Co-axial, as illustrated in Fig 3.

All three types have certain common characteristics and show a favourable comparison in weight and space when compared with conventional side-by-side units of the same capacity and life expectation. Since the input and output shafts have no transverse forces acting upon them, there is no need for a high-speed bearing, and the low-speed bearing, which normally carries the weight of the gear assembly and acts as a location bearing, can be used to support one end of an adjacent unit such as a generator armature.

The overall efficiency of these multiple layshaft units has been the subject of considerable study and test to ascertain the extent to which the saving of the power losses in wheel and pinion bearings in a conventional unit are counteracted by the layshaft bearings plus the greater number of gears involved.

The following table giving the calculated efficiency values of a number of such units does not follow any definite sequence, being actual examples of current schemes. Tooth losses in column 'a' are calculated by the method given in Merritt's 'Gear Trains'[1] with a value of 0·08 for the coefficient of friction. The churning losses are accepted to be proportional to the gear speeds, while the bearing losses have been calculated using the formula given by Newman[2]. The resultant overall efficiencies are given in column 'A'.

A three layshaft unit built for a British turbine manufacturer was the subject of a full load test when the efficiency was found to be 97·4 per cent. When calculated by the method used in the table above, the efficiency works out at 96 per cent, which is over-conservative due to the high tooth losses obtained when using a coefficient of friction of 0·08 in the expression given by Merritt. When an empirical tooth loss of 0·7 per cent per contact is used, the calculated efficiency of this three layshaft unit becomes 97·2 per cent.

These figures suggest that, for gears with a high degree of finish and running at high speeds, the coefficient of

* Research and Development Department, David Brown Industries Ltd.

friction value of 0·08 may be too high. If this figure is reduced to 0·06, the calculated efficiency of the tabulated units is as shown in column 'B', based on the tooth loss as column 'b'.

The actual efficiency of the three layshaft unit tests was

Load hp	Speeds rpm	Unit type	Annulus diameter		Churning loss %	Bearing loss % (NEWMAN)	Tooth loss % a	Tooth loss % b	Calculated overall efficiency %	
			ins	mm					A	B
22,400	6,000/600	SC	32	813	0·5	0·36	1·27	0·95	97·9	98·2
7,000	8,000/2,700	SA	24	610	0·5	0·9	1·41	1·16	97·2	97·5
1,300	730/748	HC	24*	610	0·5	0·33	2·10	1·58	97·1	97·6
2,600	7,000/1,500	SC	17	432	0·5	0·81	1·27	0·95	97·4	97·7
2,520	10,000/1,500	SC	20	508	0·5	0·83	1·25	0·94	97·4	97·7
250	1,900/5,700	SA	8	203	0·5	0·69	1·28	0·96	97·5	97·8
7,450	5,000/1,500	SA	24	610	0·5	0·67	1·19	0·90	97·6	97·9
7,450	5,000/1,000	SC	28	711	0·5	0·48	1·27	0·95	97·8	98·1
3,360	8,000/1,500	SC	20	508	0·5	0·7	1·38	1·04	97·4	97·8

* Diameter of circle circumscribing planets—no annulus.

still slightly greater than the calculated figure of 97·2 per cent and, judging from this result, it seems probable that the actual efficiencies of the epicyclic units will approach or even exceed 98 per cent, a figure which is comparable with the efficiency of side-by-side units of normal design.

Spur gears, or, more frequently, single helical gears, are used on all externally toothed gears of these types and are profile ground to a high degree of accuracy, ensuring quietness of operation. The use of double helical gears is only possible for the high speeds involved by increasing the facewidth to permit a gap giving sufficient clearance for grinding or, when such increase in width is undesirable, nitriding the gears to control distortion.

The end thrusts from the single helical gears present no

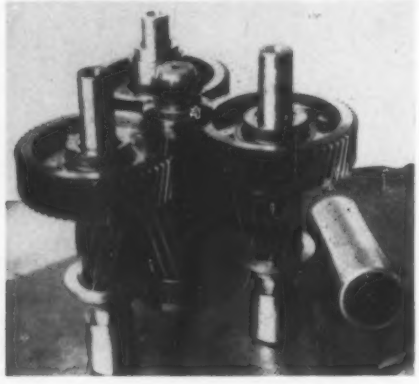


Fig 4. Rotating elements of 'HC' unit showing thrust cones

problem as these are taken on thrust cones so arranged that thrusts due to both directions of rotation are accommodated within the gears themselves and not transferred to the bearings.

One gear, usually the pinion of a mating set, is fitted with a thrust ring at each side of the face, the inner face of the rings being true conical surfaces. The side faces of the mating gears are accurately ground so as to present true conjugate conical surfaces to the thrust cones on the pinion shaft. When running they have line contact in the common plane of the shafts and offer a wedge-shaped 'lead-in' for the lubricating oil, thus ensuring hydrodynamic lubrication.

It is fairly obvious that the end thrusts on each wheel and the pinion are equal and opposite and the reactions are taken on one pair of thrust cones, depending on the direction of rotation. With single helical gears there are, therefore, no thrust loads to be accommodated by thrust collars on the journal bearings. These thrust cones have a very high load carrying capacity and, due to the rolling nature of the contact, they have little effect on the overall efficiency of the unit.

Fig 4 shows, in the upper train, a self-centralizing pinion with thrust cones in contact with the cones on the three layshaft planetary wheel rims.

At this stage it may be desirable to describe separately the fundamentals of each of the three types.

'SC' Balanced Thrust Co-axial Unit

This type of unit is used for ratios between 4:1 and 10:1 with the low-speed shaft running at speeds up to 1500 rpm.

It will be noticed that no reference has been made to 'input' or 'output' shafts as these units are equally suitable for either reducing or increasing speed. As increasing units they are very suitable for driving high-speed compressors, with motors as the prime movers, and also for driving high-speed pumps.

In the 'SC' type (Fig 1) the high-speed drive is to a self-centralizing pinion, driving three equally spaced layshaft gears revolving in a carrier which is integral with the low-speed shaft. The layshaft planetary gears also mesh with an internally toothed annulus which does not rotate, but which, due to its type of mounting, takes up a position concentric with the pinion.

This annulus mounting is an embracing flexible type coupling by which means it is flexibly anchored to the case.

Fig 5 is interesting in that it shows a spur geared 'SC' unit that was designed and built for a ship's lighting set requiring 160 kW (215 hp) normal rating at 7500 to 1250 rpm (6 to 1 ratio).

Assembled in a power circulating rig it was run for a total of 1200 hours of which 500 hours were on 50 per cent overload. On dismantling after test, all details were

found to be in excellent condition and the unit on re-assembly was ready for putting into immediate service.

This test confirmed previous investigations which indicated that this type, with the floating annulus, may be even quieter in service than the 'SA' type where the case is integral with the planet carrier.

This unit has a 10 in (25·4 cm) pitch circle diameter annulus and the height is 17 in (43·2 cm) whilst the width over both coupling faces is 15 in (38·1 cm) This gives a good idea of the compactness of a unit of this rating.

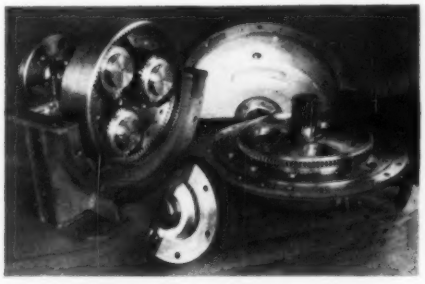


Fig 5. Partially dismantled 'SC' spur geared unit after test

'SA' Balanced Thrust Co-axial Unit

This type of unit is available for ratios between 2:1 and 9:1 with the low-speed shaft running at speeds up to 3000 rpm.

Referring again to Fig 2, it will be seen that, in this type, the layshaft carrier is rigidly fixed to the main case and that the self-contralizing annulus, located by thrust cones, is coupled, by means of an embracing gear type coupling, to the low-speed shaft.

The pinion is self-centralizing, requiring no bearings, and is coupled to the high-speed shaft extension by means of a gear type flexible coupling.

'HC' Balanced Thrust Co-axial Unit

It will readily be seen from Fig 3 that this type of unit is entirely different from the 'SC' and 'SA' types as it is not epicyclic, which is obvious from the fact that there is no annulus, and that it is, in the most simple terms, a three layshaft double reduction gear unit.

It has, however, an important factor in common with the other types in that both high- and low-speed sun pinions are self-centralizing and require no bearings, being connected to the high- and low-speed shaft extensions by gear type flexible couplings.

This type of unit is suitable for speeds and ratios which are outside the range of the 'SC' and 'SA' types. Any ratio between 1·5:1 and 30:1 is obtainable and high-speed shafts running at up to 30,000 rpm are accommodated. Gas turbine transmissions are catered for by this arrangement.

The high-speed drive is taken from a self-centralizing pinion to three compound layshaft gears and is thence returned to another self-centralizing low-speed gear.

As in all split drives, it is essential that each of the layshaft gears shall carry its share of the load and this is made certain by the design of the layshafts and the method of assembly adopted. In addition to the high degree of accuracy in centre distance and spacing attained for the three layshaft bearing bores in the gear-case, the two sets of teeth on each layshaft are set in precise relationship to each other by making the layshaft wheel in the form of a rim and reaming the fixing bolt holes for fitting bolts on final assembly.

Fig 6 shows this unit mounted in position and well illustrates the convenient disposition of the auxiliaries.

In the 'HC' type gear, when the unit is used as a reduction gear and coupled to a single-bearing alternator, the low-speed bearing is enlarged and located, but where the low-speed shaft is connected to a two-bearing machine, the low-speed bearing is omitted.

Gear Type Couplings

The double gear couplings incorporated in all balanced thrust co-axial units are essential to the satisfactory operation of the gears and are integral parts of the units. They all have barrelled teeth.

Additional flexible couplings between the units and the driving and driven members of a set are therefore not required, and either solid forged coupling flanges or bare shaft extensions can be provided according to the requirements of the prime movers and the driven machines.

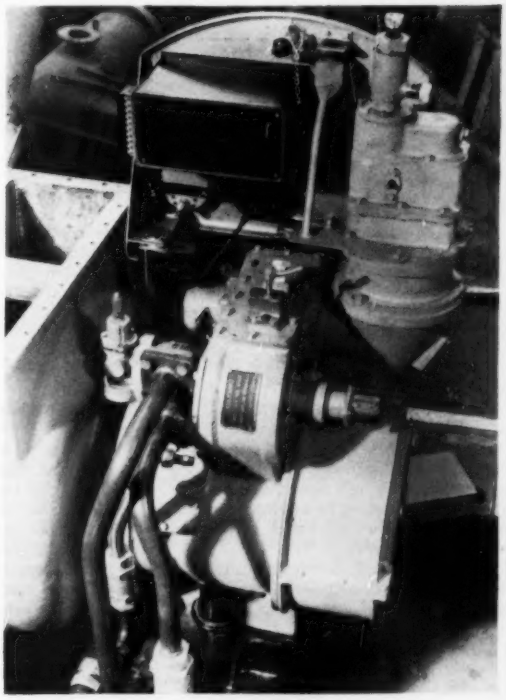


Fig 6. 'HC' unit with auxiliaries in position

Gears

With the high peripheral velocities which may be attained, the gears must be of the utmost precision and all gears, with the exception of the internal tooth ring, are case-hardened and finally profile ground to BS 1807 class A1 requirements.

The internal gears are generated with a gear type generating cutter, or, if of sufficient size, internally hobbed.

REFERENCES

1. Merritt, H. E. 'Gears', Ref 13.6, p 245. Pitman, 1955.
2. Newman, A. D. 'Bearings for Marine Geared Turbines', *Proc NE Coast Inst Engrs & Shipbuilders*, 1956, **72**, p 211.

New equipment and processes

Low Cost Process Timers

From *Lancashire Dynamo Electronic Products Ltd*, Rugeley, Staffordshire, comes news of a range of economically priced electronic process timers. Known as Series PCT 1, they are available in six basic forms depending on the required time range, and they can be connected together to provide multi-stage timing control for complete processes.

The six basic models are designed to provide time ranges respectively of 0·1-1·5, 0·3-5, 1-15, 3-50, 10-150, and 30-500 seconds. Each main time range is subdivided into 'Long' and 'Short' ranges selected by a switch, and a continuously variable control is provided for accurate setting of the required time interval. The units have a repeat accuracy of ±1 per cent on a stable supply and variations in supply voltage of −15 to +10 per cent will not cause more than ±5 per cent change in the set time interval.

The timers are housed in a substantial cast light alloy case which is designed for wall or base-mounting. Suitable sealing arrangements are provided on the detachable covers to prevent the ingress of dust and moisture. The timing controls are mounted on the front of the case, the time-setting control being provided with a scale calibrated directly in seconds. The timers are designed for 200/250 or 110/115 V 50/60 c/s single-phase supplies.

All models are available from stock.

Flameproof Metering Panel

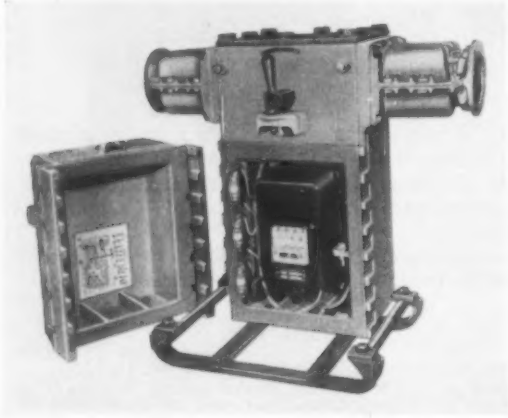
This equipment has been introduced by *Siemens-Schuckert (Great Britain) Ltd*, Brentford, Middlesex, to enable the common practice in industry of metering the consumption of a single machine or perhaps a group of machines to be extended to locations such as coal-mines where flameproof equipment is essential.

The type BMP 9 flameproof metering panel comprises a flameproof tank with two separate flameproof chambers, the upper having three busbars rated at 300 A, the necessary current transformers, and an isolating switch; the lower chamber having a 3-phase 3-wire unbalanced load, a 2-element integrating watt-hour meter, together with fuses. The meter itself is of the standard industrial pattern.

The front cover of the tank, which is interlocked with the isolator, is of the 'single-lock' type, which dispenses with a multitude of cover bolts and with which it is only necessary to turn a single screw to remove or replace a cover. As the unit is intended for use near the coal-face and other dusty situations, no window is provided, the quick release cover ensuring that only a minute or two need be occupied in removing the cover, reading the meter, and replacing the cover.

The busbar flange dimensions of the metering panel are the same as those specified in the British National Coal Board Specifications covering 'standard' gate-end panels, so that the metering panel can be lined up with a bank of 'standard' panels at the incoming side. By using flit plug adapters, the metering panel can be inserted in the main cable run at any required point. If the consumption of a single machine is to be checked, the metering panel can be fitted with 100 A plug sockets and inserted in the trailing cable run.

The panel has been certified flameproof and carries the Flameproof Certificate No. FLP 4046.



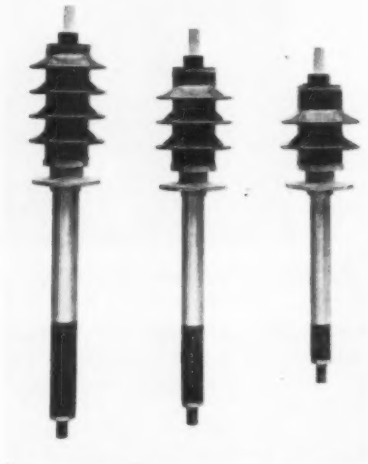
The Siemens-Schuckert flameproof metering panel for use in mines and similar locations

Apparatus Bushings for the North American Market

In introducing a new range of 'Dialam' apparatus bushings to meet North American (NEMA/CEMA) specifications, *Permali Ltd* of Gloucester state that the adoption of an interchangeable unit will greatly simplify the supply of replacement bushings for the North American market and the stocking problem of manufacturers and utilities.

The new range has been designed as a standard interchangeable oil circuit-breaker and transformer bushing and is supplied for all standard ratings from 8·66 to 69 kV, 1200 A.

In construction, these bushings are of a generally simple and robust design. There is no conservator head and a spring washer assembly reduces the short air length. The insulating core is manufactured from a grade of bakelized paper giving high thermal stability and low dielectric loss characteristics, plus good mechanical strength and resistance to moisture. Thin metallic foils are inserted during the wrapping process to provide conducting layers for controlling both axial and radial stresses.



A group of the apparatus bushings to NEMA/CEMA specifications introduced by Permali Ltd.

A further feature of these bushings is that their fitting and maintenance has been simplified.

Toroidal Voltage Regulators

A new range of toroidal voltage regulators has recently been announced by *Foster Transformers Ltd*, South Wimbledon, London, SW19, to which the trade name of 'Troidac' has been given. Four basic sizes will be marketed: Troidac 2·5, Troidac 10, Troidac 20, and Troidac 40. Of these, the 2·5, 20, and 40 sizes are in production; the 10 size will be available shortly.

All units are designed for a nominal ratio of 240/270 V or 240/240 V. Additional tappings are provided at approximately 25, 50, and 75 per cent of the winding for use with auxiliary transformers.

The Troidac 2·5—rated current 2·5 A, maximum 3 A—is of unusual construction in that the core and the winding, apart from the brush track, are encapsulated in polyester resin. This arrangement protects the winding against damage in the 'back of board' version and provides a fully insulated and robust portable unit. The Troidac 10 will also be a resin cast unit, while the Troidac 20 is air cooled.

The Troidac 40 is an oil-cooled unit rated at 40 A from 0 to 240 V and 35 A from 240 to 270 V. A single unit will provide approxi-

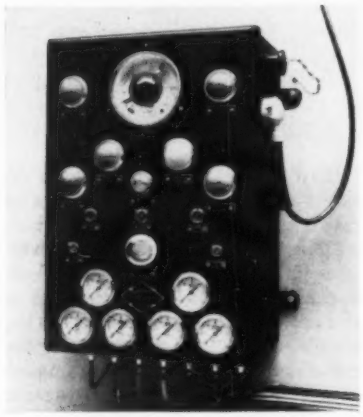
mately 9·5 kVA of control and a three-gang version can be provided. The fact that the track and brushgear on this unit are under oil is particularly advantageous in adverse atmospheric conditions.

All the regulators are wound on cores consisting of 'cold rolled' spirals and the flux density is kept low to avoid undue distortion of the output voltage wave-form.

In addition to the simple hand-operated units, these regulators will be incorporated in Foster test equipment. They are also available in motor-operated form, either as voltage regulators or as voltage stabilizers.

A Versatile Pneumatic Electric Controller

Under the name of 'Numalec', the *Cambridge Instrument Co Ltd* are introducing a new and inexpensive automatic controller with a wide range of applications in both large- and small-scale industry. The following brief description of some of its functions gives an idea of its versatility.



The 'Numalec' controller by the Cambridge Instrument Co Ltd

It will control temperature, pressure, vacuum, level, etc, each for set (adjustable) periods and in the sequence required. In controlling, for example, a complete manufacturing process, it will maintain one or more temperatures at the desired values for precise periods; govern levels, pressures, and draining; give warning of any supply failure, and indicate the completion of the process.

In its simplest form the controller will raise the temperature of, say, an electric oven to a set value, maintain the temperature for the required period, switch off and indicate completion of the cycle.

In all cases, operation is extremely simple, the sequence being initiated by pressing one button. The controller is, however, so versatile that the whole programme can be changed within three minutes.

The construction is based on standard, well-tried components and leads to a simple, reliable, and economic equipment.

A Correction

The generator unit incorporated in the Lincoln LR 150 portable welding generator described on page 28 of the February issue is the SA 150, not SA 105 as printed.

The type number indicates a capacity of 150 A.

A New Type of Water Heater

An entirely new conception in domestic water heaters, giving fast and economical heating at will of any quantity of water from a cupful to a gallon (4·55 l) is embodied in the Creda 'Corvette' recently introduced by *Simplex Electric Co Ltd.*

Very compact, measuring only 16½ in high, 8 in wide and 7½ in deep (42 cm by 20 cm by 19 cm), and modern in style and colour, it consists of a heat-resistant glass flask mounted on a base finished in red or turquoise blue, with white plastic switch and tap, chromium plated outlet pipe and flexible rubber inlet hose. It is very simple to install and no plumbing is required.

The glass flask is graduated from 1 to 8 pints (one gallon) (0·57 to 4·55 l) so that exactly the required amount of water can be heated either to any selected temperature or to boiling point for tea or coffee making. Heating is fast, and the 'Corvette' will boil a pint of water in less than 2 minutes, half a gallon in 4 minutes, and a gallon in 11 minutes. Intermediate temperatures are controlled by an adjustable thermostat, and the element is switched off and a red indicator light is extinguished when the pre-selected temperature is reached. Alternatively, a whistle blows when the water boils. A protective cut-out operates if the flask is allowed to boil dry.

The Corvette is available in two types for 200/220 V or 230/250 V supplies respectively and the loading is 3 kW.

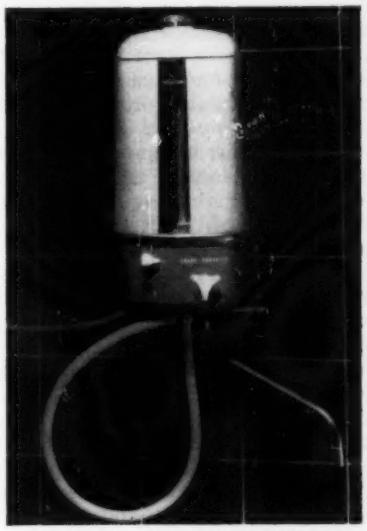
1959 'Pacemaker' Refrigerators

An outstanding feature of this year's range of 'Pacemaker' refrigerators marketed overseas by *AEI–Gala Ltd* is that they have now been fitted with rollers, so that a gentle push on one of the upper corners will roll them away from the wall for easy cleaning behind.

Another important advantage is afforded by the large stainless steel freezers in each model which are maintained at temperatures low enough to keep ice cream for as long as a week, as well as keeping frozen food packs and making ice cubes. A deep chiller tray slides under the freezer.

The two current models are the D36, capacity 3·6 cu ft (0·1 m³) with a shelf area of 6·9 sq ft (0·64 m²), and the D50, capacity 5 cu ft (0·14 m³) and a shelf area of 9·9 sq ft (0·92 m²). Both models have full width storage space built into the inside of the door. The 'no-slam' door latch introduced last year is retained.

Cabinets are of all-steel construction, bonderized for rust protection and finished in two coats of stoved enamel in white or cream, with table tops in a choice of five colours. Interior liners are of ice-blue polystyrene, giving improved insulation; the main insulation is 2 inch (51 mm) fibreglass.



The Creda 'Corvette' water heater

The unit is a Coldrator 1/10th hp hermetically sealed compressor unit guaranteed for five years. The motor has a current-operated starting relay incorporating thermal overload protection. The wire-type condenser is claimed to achieve 15 per cent greater heat dissipation per square foot (929 cm²) and takes up less external space at the back of the cabinet. Temperature control is by a variable 9-position thermostat which also incorporates an on-off switch. Models are available for ac voltages of 100/110, 200/210, or 220/250, 50 c/s; models for other voltages and frequencies to special order.

One of the AEI–Gala 'Pacemaker' refrigerators. This is model D50

Electricity at the Ideal Home Exhibition

THE purposeful march of domestic electrification in Britain was amply demonstrated at this year's Ideal Home Exhibition organized by the *Daily Mail* and held at Olympia, London, from March 3 to 30. Three aspects of this event were immediately noticeable. The first was that the electrical exhibits occupied a great deal more of the space in the Household Services section than in previous years—even encroaching on the favoured area adjoining the main entrance of the Grand Hall traditionally occupied by the Furnishing and Decoration section. Furthermore, several of the electrical exhibitors also had stands in the Domestic Labour Saving section in the gallery.

The second very noticeable feature was the great variety and range of domestic electrical appliances so attractively and informatively displayed. The Electrical Development Association's stand, for example, was a microcosm of the domestic appliance industry with over 130 items by many manufacturers. And the third significant aspect of the Exhibition was the very great public interest in the electrical exhibits.

The appliances shown were representative of practically every aspect of domestic heating, cooking, water heating, lighting, refrigeration, and cleaning, with a very wide range of choice and many new developments in each of these applications.

New Ideas in Heating

For example, the days are gone when electric heating meant no more than a 1 or 2 kW portable electric fire—efficient but often not very beautiful—carried from room to room and switched on as required. Certainly, the ever-useful radiant fire is still with us, but in its modern form even more efficient, streamlined, and compact in its portable form, and in its built-in manifestations extremely handsome. The latest designs of the well-known imitation coal and log fires by Berry's Electric Ltd are particularly fine examples, and many other built-in fire designs were notable combinations of beauty and efficiency.

The infra-red principle is rapidly gaining ground, both in portable and wall-mounting fires. The fact that the silica-sheathed elements of the fires are longer than the conventional open spiral elements means a wider spread of heat, and as practically none of the infra-red radiation is absorbed by the air, the heating effect on the person and surrounding objects is correspondingly enhanced. Among several fires of this type was the Dimplex model which won the silver trophy at the ASEE Exhibition and illustrated on page 64.

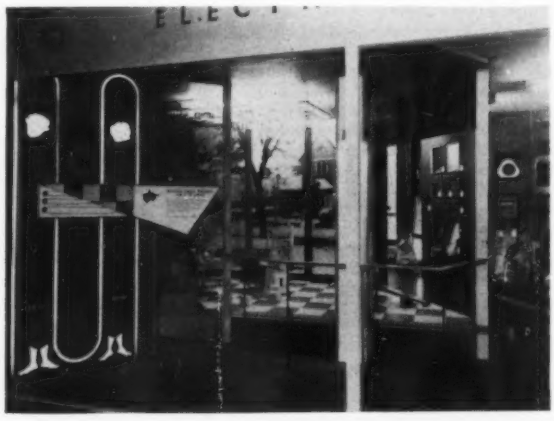
Convector heaters, both natural draught and fan-assisted types, were well represented on the stands of most of the electrical firms, and mention must also be made of the oil-filled radiators which have been marketed by Dimplex Ltd for many years.

The usefulness of all these forms of electric space heating is now considerably increased by a neat time switch which can be easily and cheaply installed on the skirting-board and which will switch on a heater at any pre-set time in a 12-hour cycle.

The latest developments in domestic electric heating are based on the concept of whole-house or whole-room heating using heat sources of large area at comparatively low temperature instead of localized sources at high-temperature, and two basic methods are gaining ground: warm air ducting in the form of the skirting-board normally running round the base of the walls of a room, and under-floor or under-carpet heating by a network of resistance wiring embedded in a concrete floor during the building of the house or laid on the floor as a carpet underlay in houses already built. A complete section of the Electrical Development Association's stand was devoted to under-floor and under-carpet heating, with explanatory displays showing how the systems work and figures demonstrating the low running costs made possible by the fact that the average price of electricity in Britain has risen in the last ten years by only 35 per cent compared with increases of 114 to 144 per cent for various solid fuels.

The increasing popularity of electric cooking was reflected in the large number and wide variety of cookers on show. The adoption in recent years of open radiant hotplates and 'Simmerstat' controls has done much to overcome the earlier prejudices of many housewives; these trends have now been carried further in such designs as the Creda 'Mercury' cooker (THE BEAMA JOURNAL, August 1958, p. 119) with its overload boost device for rapid initial heating of the hotplates and the English Electric 'Vee-line' boiling-ring (THE BEAMA JOURNAL, August 1958, p. 119).

In the last year or so, many other refinements have become standard practice on nearly all but the cheapest models: eye-level grills (about which opinion is still divided among designers and users); heated drawers or compartments for keeping food hot or for plate-warming; inner oven doors of heatproof glass; and—perhaps the greatest convenience of all, especially to the housewife



A part of the Electrical Development Association's stand devoted to floor-warming systems

who is out all day—the auto-timer control that will preset both the switch-on time and the cooking period.

It is not without interest to note that all these features which were pioneered by the various makers of electric cookers have since been adopted by their old rivals the gas cooker manufacturers, and among the gas exhibits at this year's exhibition were gas cookers with electric auto-time control panels!

Another section of the EDA stand with displays of cookers on the right and refrigerators on the left

The 'Split Cooker' Gains Ground

The outstanding feature of this year's designs was undoubtedly the 'split cooker'. This breakaway from the conventional arrangement of putting the oven at the bottom of the cooker was first introduced into this country by English Electric two or three years ago with their raised oven model in which the oven was placed above the hob and therefore at eye-level. They also showed it as a true 'split cooker' with the hob and oven units side by side. In its 1959 version, with various improvements, it was again a prominent exhibit.

This trend is growing, albeit slowly, and two other long-established cooker manufacturers—Tricity and Jackson—were showing new models designed as two or three separate units: the oven with auto-timer and thermostat control, the hotplate or hob, and a warming cupboard.

This arrangement means that the units can be installed in any desired position in a kitchen and each of them can be at the most convenient height. They can be mounted on tables, benches, or cupboard units, or built in as part of an integral kitchen design—a logical extension of the growing trend towards built-in sinks, cupboards, and other kitchen furniture.

More Small Refrigerators

It is a debatable point whether refrigerators or washing machines came next after cookers both in numbers and variety on display and the amount of public attention they received. Among the former were several new designs incorporating some novel features, as well as many established models with recently added improvements and refinements.

One noticeable trend is the advent of a number of smaller refrigerators of 2 or 2·5 cubic feet (0·057 or 0·071 m³) capacity and of the absorption type. For the larger models the hermetically sealed compressor unit is still supreme, but for these small cabinets the more compact dimensions and simpler (and therefore cheaper) construction of the absorption unit have obvious advantages.

Prominent among these newcomers was the Jackson, with a capacity of 2 cubic feet but giving 3·4 square feet (0·316 m²) of shelf area. Its external measurements are only 21½ inches (54·6 cm) wide, 22¾ inches (57·8 cm) back to front, and 34 inches (86·4 cm) high including the optional table top and floor stand. An outstanding design feature is the all-plastic cabinet which is a one-piece moulding.

Another newcomer was the Sterling-Electric 2·3 cubic feet (0·065 m³) model, giving approximately 4 square feet (0·37 m²) of shelf area. This has a white enamelled metal cabinet with a pastel green plastic interior lining, with the additional refinements of a choice of left- or right-hand door and automatically controlled interior light.

Door Storage Now Standard Practice

The General Electric Co have also entered this field with their 2·5 cubic feet (0·071 m³) 'cabin-sized' model providing over 5½ square feet (0·51 m²) of shelf area. It has no protruding handle and is styled in the new 'squared up' fashion. GEC, in common with all the other refrigerator makers, were of course showing all their other models ranging up to 8 cubic feet (0·23 m³) capacity and including their 'Fabulous Four' (a 4·1 cubic foot (0·11 m³)) table-top model introduced last autumn. Mention must also be made of the English Electric 'Slim-line' (THE BEAMA JOURNAL, May 1958) shown filled with food and prepared dishes sufficient for a family of four for three days and of which all the ingredients came from thirty different Commonwealth countries; the 1959 versions of the Hotpoint 'Pacemaker' refrigerators described on page 75 of this issue, and another new introduction—the Ada 4·6 cubic feet (0·13 m³) absorption type (unusual for a model of this size) which is mounted on rubber rollers for easy movement.

It is standard practice this year—even in the smallest models—to utilize the whole of the inside of the door for storage space, usually with special compartments for butter and racks for eggs and bottles.

Home Laundry Equipment

Washing machines, wash boilers, and spin driers have been the subject of steady development and improvement, with particular reference to still easier handling and greater convenience in use, especially in the filling and emptying operations of the boilers and washing machines.

Power-pump emptying is in fact an essential feature of a modern washing machine and was incorporated in every model shown at the Exhibition. This does not necessarily apply to wash boilers and spin driers, and only one of the boilers on show had this feature—the Burco. Among spin driers, too, the Hoover 'Spinarinse' (THE BEAMA JOURNAL, February 1959) is distinctive in having a power pump for emptying.

The new English Electric washing machine goes one step further in having a pump and *two* hoses, so that fresh rinsing water enters at the top while the washing water is being pumped out from the drain placed under the agitator.

In most cases, domestic washing machines and spin driers are separate appliances, but there are exceptions. One is the Parnall 'Thor' which washes, rinses, and spin dries in the one tub. Others are the new 'Ada-matic'

combined washer and spin drier and the 'Hoovermatic', in which the two units are separate but built side by side into one cabinet. The Hoover 'Spinarinse' already mentioned is a self-contained unit, but since it exactly matches the Hoover washing machine in height and styling, the two can be combined into one unit by a connector-bridge available as an optional extra.

Wide Choice of Water Heaters

It is but a short step from washing machines to water heaters, of which a great many models were to be seen. Probably the widest range by any one manufacturer was the Hotpoint series (marketed overseas under the trade name of Gala), which included attractively styled self-contained storage heaters from the small hand-basin or sink size to 'whole house' types of 30 gallons (136 l) capacity; cistern types with their own ball valve and cold water header tank built in, and immersion heaters for fitting into existing cold water tanks, the latter including the 'Twimerser'—one unit with a short 2 kW element for quick heating of the water at the top of the tank and a full-length 3 kW element for heating the whole contents of the tank, a built-in change-over switch, and one thermostat which controls each element independently. A water heater with a difference was the recently introduced Creda 'Corvette' described on page 74 of this issue.

Suction cleaners do not change basically from year to year, but many of them appeared this year with detail improvements in design and more attractive styling. One completely new model was the Parnall 'Tenten' which was also shown at the ASEE Exhibition, where it earned a 'Highly Commended' award from the judges. (See page 64.)

It is interesting to note that the huge expanse of carpet covering the main and side aisles of the Grand Hall, adding up to one of the largest carpets in the world—19,000 square feet (1765 m^2) of it—was cleaned daily with Hoover cleaners. When we visited the Exhibition on the last day, after more than a million people had walked over the carpet, it still looked as fresh as on the opening day.

British Government Pavilion from Brussels

In this necessarily brief review it has not been possible to do more than touch on the highlights of the great range of domestic electrical exhibits, but before concluding the story, mention must be made of one of the outstanding features of the Exhibition as a whole—the British Government Pavilion which was brought from the Brussels Exhibition last year and re-erected in its entirety in the Grand Hall at Olympia. Needless to say it attracted enormous interest, and many of Britain's pioneering electrical achievements portrayed therein provided a stimulating background to the more homely appliances which in their own field are equally outstanding examples of first-class design, excellent engineering, and traditional British quality.

New Range of Floor Maintenance Equipment by the Pioneers of Vacuum Cleaning

AFTER extensive tests and stringent practical service with the prototypes produced in the summer of 1957, the British Vacuum Cleaner and Engineering Co Ltd, Goblin Works, Leatherhead, Surrey, have now entered the floor maintenance field with a versatile range of new machines. This event marks an important step in the BVC Group's policy and, incidentally, closely follows a historic event—the presentation by the Group to the Science Museum, London, of the world's first vacuum cleaner, which was invented in 1903 by the late H. Cecil Booth, the Group's founder and Chairman until his retirement in 1952.

This original machine was designed to operate from the kerbside, with hoses passed through the windows of the house to be vacuum cleaned. By modern standards it was a large and heavy machine (although it did its work very efficiently), but it ranks as the forerunner of all the large and small industrial and domestic vacuum cleaners that have evolved since that time.

After the first world war the company changed its title to the British Vacuum Cleaner and Engineering Co Ltd to match the expansion of its interests into wider fields of engineering. In 1937 it acquired the Magneta Time Co Ltd, at that time manufacturing and selling master clocks and time recorders. After the end of the second war, new factories were developed in Scotland (for the manufacture of washing machines) and in Northern Ireland. More recently, the Group has entered the field of specialized motor construction for electronic requirements and this is in the hands of a newly formed subsidiary, BVC Electronics Ltd.

During the half-century or more of its existence, the Group has consolidated its position as one of the large manufacturers of domestic appliances (notably its 'Goblin' range), and its specialized achievements in the industrial field all over the world have been considerable. These have included the largest pneumatic conveying system yet employed by British industry, and the manufacture

The world's first vacuum cleaner photographed in the Science Museum, London

of the world's largest mobile vacuum cleaner—a 14-ton machine measuring more than 20 ft (6 m) long, designed for heavy-duty boiler cleaning at pitheads and steelworks.

Now the Group has turned its attention to another aspect of commercial and industrial cleaning which has already grown into an industry in its own right—floor maintenance equipment. Some of the early models of the new range of machines described below were seen in the British Industry Pavilion at the Brussels Exhibition last year, and in fact several of them are still employed in cleaning the large areas of carpet and flooring in the Atomium, which remains as a permanent feature on the site of the Exhibition.

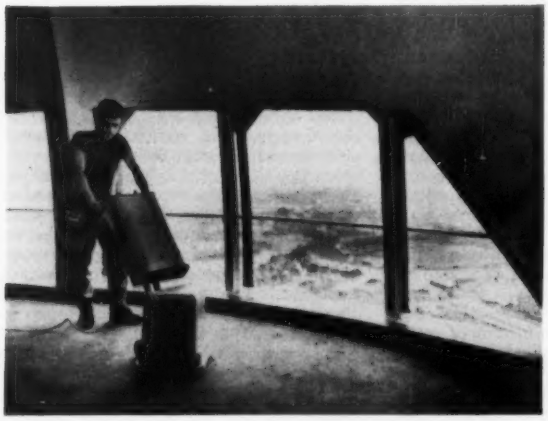
Eight Models for All Requirements

A notable feature of the new range of BVC floor maintenance equipment is its versatility. While there are basically four models, an ingenious system of conversions and adaptations produces eight different models specifically suited to every kind of floor cleaning and maintenance.

Starting with the smallest model, this is the 'Chipmunk' (Model K 30)—a single-brush commercial dry-cleaning, polishing and light sanding machine particularly adapted for reaching under furniture, desks, or beds. It is notably silent in operation, and has in fact worked effectively in hospital wards in which patients were still sleeping.

By the addition of a liquid tank to take detergent, this machine becomes the 'Musquash' (Model KW 30) and can undertake the additional tasks of floor mopping, scrubbing, and carpet shampooing.

Next comes the 'Hedgehog' (Model K 10)—a very much heavier industrial type of machine with two meshing brushes, thus covering a wider area. Driven by a 1 hp motor, it is capable of the heaviest work on factory floors, on shipboard, and similar locations. The makers claim that, when fitted with heavy spring-steel wire brushes, it



A 'Hedgehog' in use in the Atomium in Brussels

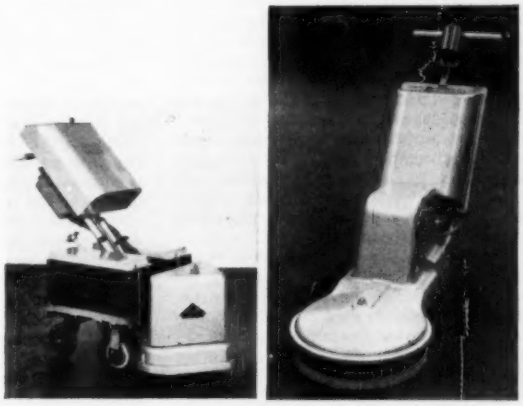
will scour and remove hardened and solidified oil, grease, or other material from concrete and similar floors which otherwise could be shifted only with a hammer and chisel. Yet, with suitable brushes, it can be used for polishing the finest ballroom floors.

Then, by the addition of a liquid tank and sprinkler system, the 'Hedgehog' is converted into the 'Otter' (Model KW 10), suitable for all heavy-duty wet scrubbing operations.

In a further variation, both the 'Musquash' and the 'Otter' can be fitted with batteries enabling them to be used for the same operations as their mains-driven counterparts in situations where mains supplies are not readily available or where trailing cables would be inconvenient.

Two models which complete the range are the driers, specially designed to remove water or detergent solution with the greatest possible speed after wet scrubbing. These are the 'Ferret' (Model K 40), designed primarily to work with the 'Musquash', since it will dry under furniture, beds, and so on, and the 'Vampire'—the companion machine to the 'Otter' with a tank of the same size. The 'Vampire' is available only as a battery-driven model.

Both these drying machines are stated to be rapid in action and suitable for all types of floors, their wide squeegees—19 in (53 cm)—giving effective pick-up even from irregular surfaces and undulating floors.



(Left) *The battery version of the 'Otter' and* (right) *the single brush 'Musquash'*

BVC have developed their own range of detergents and polishes, a special sprayer for the application of polish, and they also offer a very wide range of brushes to deal with any special cleaning or polishing problem.

Portable Models for Aircraft

Another interesting activity of the BVC Group is in the field of vacuum cleaning of aircraft. Many British and French airliners now carry their own vacuum cleaners with them—special portable machines fitted with 28 V motors and anti-static equipment made and supplied by BVC. With these, the cleaning of floors, seats, and cabins can be carried out as and when required by the operating companies and the aircraft are largely independent of the local cleaning facilities at the airports at which they call.

BVC has played a prominent part in providing vacuum cleaning for the Air Forces and civil air lines of the world. Since 1940, at least, the Royal Air Force has used heavy industrial models specially designed for its needs, and at the present time BVC equipment is used by the air forces of Belgium, Egypt, India, the Netherlands, Norway, Pakistan, Rhodesia, and U.S.A. Civil air lines include British European Airways and Air France (the only lines at present using the new low-voltage machines carried in the aircraft), Aer Lingus, KLM, Swissair, El-Al (Israeli) Air Lines, Qantas, and Egyptian Air Lines. BOAC use heavy-duty machines operated by compressed air motors, and among fixed installations is a large plant supplied to Oslo Airport.

Book Reviews

Transistor Technology. *Vol 1. Edited by H. E. Bridgers, J. H. Scaff, and J. N. Shive.* $9\frac{1}{4} \times 6\frac{1}{4}$ *in* (235 × 159 *mm*). *Pp xxxvii* + 661. *Illustrated. Index.* (*London: D. Van Nostrand*, 1958.) Price 131s 6d net.

The birthplace of the transistor, the Bell Telephone Laboratories, is the logical home of an authoritative book on the device, and the present work gives good support to that belief. It is the first of three volumes that will endeavour to provide a bridge between laboratory techniques and full-scale industrial production of transistors.

The opening chapters of the book cover the detailed technology of germanium, including purification by zone melting, the reclaiming of waste material, and a comprehensive survey of the whole subject of growing the best single crystals.

Then follow nearly three hundred pages dealing with the making of transistors, including a chapter on the theory of transistor design. The methods used in making point-contact and grown junction transistors are described in some detail, but the alloy techniques are not mentioned. This produces a degree of unbalance, because point-contact devices are practically obsolete, and are only thought of in the historical sense, whereas alloyed junction transistors are the most common kind produced to-day. But it will be possible to correct this matter in a later volume of the work.

The closing chapters deal very comprehensively with the matter of transistor characteristics, small signal, large signal, and pulse parameters, and the various methods of determining them.

There are two short chapters at the end of the book on transistor reliability, and although it is understandable that comparatively little can be written about this subject at the present time, it is to be hoped that future editions of the work will see these chapters very much expanded, because a comprehensive and scientific approach to the measurement of transistor reliability is essential to a more widespread use of the device in engineering.

J. H. J.

Interference between Power Systems and Telecommunication Lines. *By H. R. J. Klewe.* $9\frac{1}{4} \times 7\frac{1}{4}$ *in* (248 × 184 *mm*). *Pp. viii* + 256. *Illustrated. Index.* (*London: Edward Arnold*, 1958.) Price 70s net.

When it is mentioned that the bibliographical record given in this book contains 639 items of books, papers, and reports relating to practically all the features that can be thought of or have been encountered in interference theory and practice, it will be realized that the subject is one to which a vast amount of attention has been given. The record covers the years 1881 to 1957 and it embraces the work done in Great Britain, the USA, the Continent of Europe, and several other countries.

In 1922, The Electrical Research Association set up a committee of experts in power and communication electrical engineering to study the subject and to report upon ways and means by which interference arising from the manifold aspects of power system design and operation could be eliminated, or brought within limits acceptable to those responsible for maintaining the necessary standard of interference-free service of communication in Great Britain: namely, the General Post Office. The committee is still in being and the results of its work have been made public by the ERA through a steady flow of technical reports prepared by their investigators and endorsed by the committee.

The present volume is a culmination of all that has been done by the ERA and in which Dr Klewe has played a leading part. Sir Gordon Radley, in the Foreword, says: 'Now all the information that is available has been brought together by Dr Klewe in this book. It should be of immense benefit to all who are concerned with the construction of power and communication lines. . . . All the basic information required by the engineer is . . . contained in this useful book.' Dr Klewe, very properly, is more modest when he says in the conclusion that '. . . this book . . . can contain only an extended summary and outline', although none the less '. . . the contents . . . should give a general understanding of the problems and serve as a base for the study of specialized publications or the treatment of questions not here touched upon'.

Both writers are, of course, correct. We agree with Sir Gordon on the 'immense benefit' to be derived from the book, and with Dr Klewe that a single volume of 256 pages cannot be expected to include all that has been covered in 639 other publications.

The book opens with a brief introductory chapter on the history of the subject, subsequent ones dealing with the theory of the coupling between circuits, power system characteristics and phenomena affecting telecommunication systems adversely, effects in telecommunication circuits arising from interference peculiarities and sensitivity of these circuits, telephone interference by induction at audio-frequencies, effects to be considered for different types of power lines and telecommunication lines—limits and approximate formulae, reduction of interference, hints for practical calculations and examples, and conclusion. There is an extensive bibliography and an index.

In these chapters the author deals with all the topics that are relevant to the general interference problem as, for instance, electric and magnetic induction, earth wires, soil conductivity, types of power lines, conductor configurations, transpositions, power line faults, earthing methods, fault currents, harmonics and their effects, dangers on the communication system, dc and ac railways, remedial measures, examples of interference by dc railway, ac railway, a 33 kV three-phase line with insulated neutral, and a 275 kV line with earthed neutral.

The book is well illustrated and the mathematics consists mainly of relevant formulae.

Prior to the appearance of this book, those best known to both power and communications engineers were probably Inductive Interference between Electric Power and Communication Circuits published in 1919 by the Railroad Commission of the State of California (a magnificent piece of work) and the plenary meetings volumes of the CCIF which was founded in 1924. Dr Klewe's book is well worthy of a place alongside these compendia, and it has the additional merit of modernity. It can be recommended as indispensable to all electrical engineers to whom system interference is a problem.

S. AUSTEN STIGANT

The Performance and Design of AC Commutator Motors. *By E. Openshaw Taylor.* $8\frac{3}{4} \times 5\frac{1}{2}$ *in* (222 × 140 *mm*). *Pp xviii* + 350. *Illustrated. Index.* (*London: Sir Isaac Pitman & Sons*, 1958.) Price 45s net.

It is well known that little attention is given to electrical machinery in many undergraduate courses and that the subject is not popular with students. The reasons for this decline and lack of interest in electrical machines are difficult to elucidate. It is educationally unfortunate that so many undergraduate courses in electrical engineering are specialized along narrow channels. Such courses often neglect the subject of electrical machines after the elementary or Part I stage.

The present book is intended to form a companion volume to Professor M. G. Say's book on the *Performance and Design of AC Machines* and to Dr A. E. Clayton's book on the *Performance and Design of DC Machines*. The general layout, style, and format of this new volume follow closely the pattern of the other two books.

The text, comprising 20 chapters and two appendices, is illustrated with 225 line diagrams and 21 tables. The subject matter covers winding and magnetomotive force, electromotive force, commutation, effect of electromotive force injected into the secondary circuits, regulating machines giving an electromotive force independent of current or voltage, types of three-phase commutator motor (double-fed, Shrage, no-lag, and series), and the single-phase motor (universal, compensated series, repulsion, induction, shaded-pole and capacitor types). The two appendices provide notes on harmonic analysis and the current loci of the R-L series circuit. Since both of these topics are standard electrical circuit theory and will be covered by existing books they could well be omitted; these topics are not peculiar to electrical machinery.

The author has provided 76 examples with answers for solution by the reader in order to test the knowledge he has gained from the text. These questions are mostly original, since the author indicates that there is a general shortage in the literature of the subject of suitable text questions which deal with the ac commutator motor.

The text has been compiled with careful attention to the nomenclature, abbreviations, and units employed. Stress is laid on the need to use new terms for both the rotating vector and vector diagram. The author adopts complexor and complexor diagram

throughout this work for these two terms. Since it is noted that other authors use instead phasor and phasor diagram, it would seem desirable for this question of nomenclature to be settled at an early date.

Almost all the material in this book is basic knowledge, but the quantity is so great that some selection would probably have to be made for use in a general degree course in electrical engineering.

The text is well written and very readable. The book has an attractive format and a clear type. It is thoroughly recommended.

P. F. SOPER

Electricity and Magnetism to Advanced and Scholarship Level. *By C. G. Wilson.* $8\frac{3}{4} \times 5\frac{1}{2}$ *in* (222 × 140 *mm*). *Pp xiv*+ 538. *Illustrated. Index.* (*London: English Universities Press*, 1958.) Price 21s net.

This new book on electricity and magnetism is one of a series of books on the physical sciences prepared under the general direction of Sir Graham Sutton, and each book has been written by a member of the academic staff of the Royal Military College of Science at Shrivenham. The series aims at providing a set of thoroughly sound textbooks, adequate both in quality and quantity of contents for the needs of students in the science sixth forms of schools. The general editor in his foreword claims that the accumulated teaching experience of the author over many years in the fields of physics and mathematics gives this new book an integrated entity.

Although the book is intended essentially to assist students preparing for examinations, care has been taken to give the subject reality. At the same time the author has avoided introducing arid abstractions. He has, however, as all books on physics preparing students for university courses should, paid attention to the reasons why particular techniques are selected for given measurements.

The text of 16 chapters, illustrated with 302 line diagrams, discusses successively electrostatics, magnetism, the fundamental laws of the electric circuit, measurement of resistance, instruments, electromagnetic induction, magnetic properties of materials, alternating currents, generators and motors, cathode rays, electrons, electrar-physics, X-rays, radioactivity and atomic-structure, nuclear physics, and, lastly, additional magnetism and electrostatics.

Since this is a textbook intended to assist students who are studying for the advanced level examination in physics at the General Certificate of Education, there is distributed throughout the text a total of 87 fully worked numerical examples to emphasize the application of the theoretical conceptions. Also at the end of each chapter there are a number of problems, 265 in total, to give the student experience with the solution of typical examination questions.

Although the treatment of the subject employs the MKS system of units, the author has not discarded classical conceptions. The theoretical conceptions of the text are based upon the inverse square law and use the fundamental ideas of point charge and point poles. The author considers that this approach has many advantages and indeed there are, particularly in the case of those readers who have had prior instruction based on classical conceptions. The author is to be commended on his uses of the Laplace Law as a basic starting-point in field strength problems.

Many consider that this approach does not confuse students so much, and the pedantic background of alternative methods is readily sorted out when a wider knowledge of the subject has been acquired.

This book is a welcome addition to the literature and will be of immense value to all who are preparing for the advanced level examination in physics of the General Certificate of Education. The clear, straightforward treatment does not shirk the recondite parts of the syllabus. It is thoroughly recommended.

P. F. SOPER

Principles of Electronics. *2nd edition. By H. Buckingham and E. M. Price.* $7\frac{1}{2} \times 5$ *in* (190 × 127 *mm*). *Pp.* 419. *Illustrated. Index.* (*London: Cleaver-Hume*, 1958.) Price 17s 6d net.

This is the second edition of this popular first principles book on electronics. There are many minor improvements to the first edition and two completely new chapters have been added: one on junction rectifiers and transistors, and the other deals with magnetic amplifiers and transductors. Chapter 5—'Conductors, Insulators and Semi-conductors'—has been revised and extended in the light of recent work in this field. Another new feature is the inclusion of a number of test questions with answers at the end of the text. The book is subdivided into three main divisions. The first division of five chapters deals with basic principles and theory; the next six chapters give a description of common electronic devices and their principle of operation, and the remaining division is devoted to explaining how electronic devices can be applied in engineering and other industrial fields. Mainly intended for the student, the book should also prove useful to managers, production engineers, and others who require some background and practical knowledge of electronics in their own particular field.

Metal Rectifier Engineering. *By E. A. Richards.* $8\frac{3}{4} \times 5\frac{3}{4}$ *in* (222 × 146 *mm*). *Pp viii*+ 209. *Illustrated. Index.* (*London: Sir Isaac Pitman*, 1958). Price 37s 6d net.

Comparatively little has been written on the application engineering of metal rectifiers, and the present work fills a definite gap in the literature of the subject. It was written by an engineer who, before his death, was an authority on the selenium rectifier, and it is around this device that the book has been planned. The other semiconductor rectifiers using copper oxide, copper sulphide, germanium, and silicon are mentioned, and it is probable that much more will be said about the last two when a second edition is required and someone is induced to follow up the good start that has been made.

Some of the very useful information with regard to metal rectifier practice is applicable to all semiconductor rectifiers, and the book can be recommended particularly to the designer who wishes to use these rectifiers. The chapters include basic rectifier calculations; losses and efficiencies (selenium only); electrical and mechanical design of stacks (selenium only); rectifier transformers; design of equipments; harmonics and smoothing; and methods of voltage control.

In some parts of the book the data supplied are obviously based on the selenium rectifier, and it would have been useful if some indication could have been given as to the direction in which these data should be modified when considered in relation to germanium and silicon rectifiers. These devices are relatively new and are rapidly becoming important, though it is not likely that they will displace the selenium rectifier, at least not for many years.

Another matter that could well be dealt with in a future edition is the critical comparison of the various semiconductor rectifiers, to show where each type could be used to the best engineering and economic advantage.

J. H. J.

Theoretical Electromagnetism. *By W. R. Myers.* $8\frac{1}{4} \times 5\frac{1}{2}$ *in* (222 × 140 *mm*). *Pp. xii*+ 274. *Illustrated. Index.* (*London: Butterworths Scientific Publications*, 1958.) Price 42s net.

This book is written for undergraduates reading for an honours degree in physics, and it is assumed that they are familiar with electricity and magnetism up to intermediate BSc or advanced level GCE examination standards. It is essentially confined to such readers.

The scope of the work is electrostatics, magnetostatics, electromagnetic induction, Maxwell's equations and circuit concepts, electromagnetic waves, and examples in electrostatics, with four appendices on vector methods, Coulomb's law of electrostatics, the Maxwell-Green reciprocation theorem, and units, dimensions, and conversion factors.

Even if the subject is becoming somewhat hackneyed, one can say that it is here presented in an attractive modern guise which will appeal at least to the present generation of university students.

The rationalized MKS system of units is employed, and a table of dimensions and factors for converting to unrationalized cgs units is provided.

However, we do not think it is good enough, in a student textbook, to deal so cavalierly with examples in electromagnetism as to leave them to be '. . . solved by simple extensions of the mathematical procedures outlined in these electrostatic examples . . .', when 'only a few examples are discussed within the main text'.

We hope the author will remedy this defect in the next edition of what is a really useful work.

S. AUSTEN STIGANT

Solution of Problems in Electrical Technology. *By H. Cotton and P. V. Parry.* $7\frac{1}{2} \times 5$ *in* (190×127 *mm*). *Pp. xi* + 315. *Illustrated. Index.* (*London: Sir Isaac Pitman & Sons*, 1958.) Price 20s net.

This new book on the solution of problems in electrical technology has 228 graded worked examples together with a further 119 problems for which the answers only are quoted. The problems have either been developed by the authors or derived from examination papers of the Universities of London and Nottingham, the Institution of Electrical Engineers, or the City and Guilds of London Institute.

The text of 18 chapters classifies the problems into those associated with units, electromagnetics, electrostatics, dc networks, generators and motors, feeders and distributors, electrolysis, batteries and thermo-electricity, ac fundamentals, circuits and networks, polyphase currents, transformers, alternators, synchronous motors and rotary converters, induction motors, power factor improvement, electronics, electrical measurements, and illumination.

Each chapter of examples begins with a short note on the relevant principles with the rationalized MKS system of units employed throughout the text. The authors state that the problems have been chosen to cater for the needs of students taking the first two years of the engineering degree course or following the Ordinary and Higher National Certificate course in electrical engineering.

Although many authorities deprecate the use of worked solutions by students, the present authors claim that such solutions teach students to present their work in a neat, logical, and orderly manner.

The format of the book is attractive, with the text printed on glossy paper. The binding and style are those associated with this printer, giving an attractive appearance to a handy pocket volume.

P. F. SOPER

A Guide to Nuclear Energy. *By R. F. K. Belchem.* $7\frac{1}{2} \times 5$ *in* (190×127 *mm*). *Pp vii* + 77. *Index. Illustrated.* (*London: Sir Isaac Pitman*, 1958.) Price 10s net.

This little volume admirably lives up to its title. In the words of its author, it is 'an attempt to explain to persons without specialized knowledge the theory of nuclear reaction and the manner in which nuclear power reactors function'.

The first chapter deals effectively with the basic principles of nuclear fission, although some degree of over-simplification has had to be used in order to bring this complex subject within the scope of readers with limited technical knowledge.

Chapter 2 describes the basic constituents of a nuclear reactor, but confines itself to the British Calder Hall type of reactor. Other designs and variations are covered in Chapter 3 (the longest chapter in the book), which classifies reactors in six groups according to their characteristics; discusses types of fuels and coolants, and describes the general characteristics of ten different types of reactor.

Fuels, fuel elements, and fuel re-processing are dealt with at greater length in Chapter 4, and the remaining two chapters cover respectively conventional and rare materials of importance in reactor design, and some useful applications of radiation.

The book is adequately illustrated with clearly drawn diagrams.

The nuclear energy industry has introduced new concepts and a new language into the business of electricity generation, and many people beside the technical staffs of firms directly concerned need a basic knowledge of the subject of nuclear power. They will find it in this book.

British Instruments—Directory and Buyers' Guide. $11\frac{1}{4} \times 9$ *in* (286×229 *mm*). *Pp* 322. *Illustrated.* (*London United Science Press.*) Price 44s net.

This is the first edition of this directory and buyers' guide of British instruments. It is produced in association with the Scientific Instrument Manufacturers' Association of Great Britain and contains information provided by eleven other trade associations including the BEAMA.

The Directory and Buyers' Guide covers scientific and industrial instrumentation for research and production in the following main fields: measurement and control of temperature, pressure, humidity, flow, weight, texture, dimensions; inspection and gauge testing, manual and automatic; data processing, computers; optics, ophthalmics, navigation, meteorology, microscopy, astronomy, surveying and levelling; physics, mechanics, pneumatics, hydraulics and electrics; analysis; laboratory ware; atomics, electronics, and nucleonics. Altogether, some 2500 instruments and components are featured in the classified list.

The ten Sections in the directory are: (1) associations allied to the instrument industry, (2) British Standards Specifications, (3) consultants and engineers for instrumentation schemes, (4) manufacturers of prototypes and small batches. (5) Instruments and components and their manufacturers, (6) glossary in French, German, Spanish and English, (7) addresses of manufacturers and their overseas agents, (8) selected trade names, (9) manufacturers' announcements, (10) advertisements.

Coordinate Geometry with Vectors and Tensors. *By E. A. Maxwell.* $8\frac{3}{4} \times 5\frac{1}{2}$ *in* (222×146 *mm*). *Pp* 194. *Illustrated. Index.* (*London: Oxford University Press*, 1958.) Price 25s net.

In the Introduction to this book the author makes the comment that 'The detailed study of three-dimensional coordinate geometry is at present unfashionable', and as the work is directed principally to young mathematicians we assume it is in the sphere of pure mathematics that the observation applies. If so, it is a sad state of affairs, for it exemplifies the lack of contact that so often becomes evident between the pure mathematician on the one hand and the applied mathematician and workers in the physical sciences on the other.

The subject is of considerable importance to engineers and physicists who look to the mathematicians for regular accounts of the developments that take place in this (and any other) branch of their studies. Thus, the author has rendered a real service to workers in the applied sciences by writing this book, and one hopes that it will serve to remove the charge recorded in the first sentence of this review.

Coordinate methods on the basis of the straight line and plane are covered by the first two chapters as a preliminary to the matters contained in the rest of the book. It is the author's belief that such a background is necessary for a full appreciation of vector methods, and with this we concur. The next two chapters are on vectors and tensors respectively and they embrace determinants and matrices. The treatment is, of course, on classical lines which, after all, forms the inescapable basis for applied studies. Subsequent chapters relate to the sphere and the circle, the central quadrics, the paraboloids, and the general quadric. The latter chapter is intended to provide an introduction to some of the techniques used in matrix algebra and it will be recognized as such by those familiar with matrix methods. Examples for working are given at the ends of the chapters and answers are provided at the end of the book.

It is evident that the author has devoted an immense amount of care to the writing of this work as, equally, have the printers in setting it. The book should be found of considerable value to all those working in the field of vector, matrix, and tensor analysis, both pure and applied, and to such we unreservedly recommend it.

S. AUSTEN STIGANT

Progress in Semiconductors. *Vol 3. Edited by A. F. Gibson, P. Aigrain, and R. E. Burgess.* $10 \times 6\frac{1}{4}$ *in* (254×159 *mm*). *Pp vii* + 210. *Illustrated. Index.* (*London: Heywood*, 1958.) Price 55s net.

This survey maintains the high standard of the first two volumes, and the only criticism that can be offered is that by covering a wide field the editors may force purchasers to spend money on aspects of semiconductors in which they have little or no interest.

There are seven sections to the present volume. They cover (1) the magnetoresistivity of germanium and silicon; (2) recent chemistry of germanium and silicon relating to purification, preparation, and evaluation of compounds; (3) an interim report on the alkali halides as semiconductor compounds; (4) theory and manufacture of silicon junction diodes; (5) recombination processes in relation to the lifetime of excess carriers; (6) scattering processes and the mobility of charge carriers in germanium; and (7) another interim report, in this case on the characteristics of cadmium sulphide.

J. H. J.

Classified Examples in Electrical Engineering. *Vol 1. 8th edition. By S. Gordon Monk.* $7\frac{1}{2} \times 5$ *in* (191 × 127 *mm*). *Pp* x + 147. *Illustrated.* (*London: Sir Isaac Pitman*, 1958.) Price 15s net.

This collection of electrical engineering problems, first published in 1928, has been of great assistance to students studying for professional examinations. This revised eighth edition of the first volume now contains 502 examples with the answers given in an appendix. The 43 main topics selected for inclusion have been taken from both the original volumes so as to provide a comprehensive set suitable for the use of students preparing for the Ordinary National Certificate or Diploma or Part I BSc(Eng) examinations.

The author has added an additional 171 new questions; these are marked with an asterisk.

In any revision of this excellent set of examples the author should consider deleting any reference to the symbolic solution of ac networks. At this level all students should concentrate on the use and interpretation of the vector or phasor diagram for the circuit.

Each chapter or set of topics is prefaced by a short summary of the theoretical background in order to solve the examples.

The book is thoroughly recommended.

P. F. SOPER

Transform Method in Linear System Analysis. *By J. A. Aseltine.* $9\frac{1}{4} \times 6\frac{1}{4}$ *in* (235 × 159 *mm*). *Pp* xvi + 300. *Illustrated. Index.* (*London: McGraw-Hill*, 1958.) Price 66s net.

This book is a welcome addition to the literature on the solution of linear engineering and physical problems by means of operational methods. The choice of topics and of examples chosen to illustrate these topics, the use of operational methods to give a basic understanding of the physical phenomena involved, and the statement of difficulties—and how to surpass them when they exist—all combine to make the book of outstanding value.

The basic transform used throughout the majority of the book is that of Laplace, and the first two chapters are concerned with elementary properties and applications of this transform. The impulse function is the subject of Chapter 3, which includes a discussion of the difficulties occurring at the origin when the Laplace transform is used. The solution of electrical network problems is the subject of the next two chapters, which deal with switching operations, exchange of sources, and four-terminal networks. Chapter 6 is particularly interesting, presenting the application of the Laplace transform method to problems in dynamics, in particular to gyroscopic configurations and to the motion of a satellite. Inverse Laplace transformation and operational rules are detailed in Chapters 7 and 8, while Chapters 9 and 10 present an excellent introduction to linear feedback analysis including the root-locus and Nyquist methods. After a short chapter on the solution of partial differential equations, two chapters are devoted to Fourier series and Fourier transforms respectively, in preparation for dealing with the subject of noise in linear systems. The spectral density of a noise signal is then discussed, together with the problem of Fourier representation of a random process. Finally, linear difference equations are solved by means of a suitable transform method, and the Mellin transform is introduced as an example of a transform method appropriate to the solution of certain variable coefficient differential equations. Two appendices present an introduction to the theory of functions of a complex variable and tables of operational rules and transforms for the Laplace method.

One criticism of the book might well be the desirability of including the material on complex variable theory in the text itself, rather than relegating it to an appendix. This is especially the case as many results used in the text are based directly on complex variable theory, and it is somewhat doubtful how far the reader will understand the basic ideas without prior fundamental knowledge. Nevertheless this is a relatively minor comment, and the scope and detail of the book should make it very valuable to the large number of people involved in the analysis of linear systems.

H. GOLDENBERG

Handbook of Physics. *Edited by E. U. Condon and H. Odishaw.* $10 \times 7\frac{1}{4}$ *in* (254 × 184 *mm*). *Pp* xxvi + 1504. *Illustrated. Index.* (*London: McGraw-Hill*, 1958.) Price 194s net.

This book of 1504 pages is a magnificent piece of work. The text has been prepared by a team of no less than 88 contributors, all specialists in their own particular sphere, so that the book carries the stamp of high authority. The authors have been drawn mainly from US universities and industry, but there are a few from other countries. Most, if not all, of them are names well known to those who follow the literature of the physical sciences published in the Western quarters of the world. As the emphasis in the book is on the principles of physical science and the associated mathematical techniques, the country of origin imposes no restriction upon the supreme value and usefulness of the work to physicists throughout the world.

The book is in nine Parts which, respectively, are concerned with mathematics, mechanics of particles and rigid bodies, mechanics of deformable bodies, electricity and magnetism, heat and thermodynamics, optics, atomic physics, the solid state, and nuclear physics. The number of chapters in each Part ranges from 8 to 13, the larger number being devoted to mathematics and to nuclear physics. Thus, both classical and modern physics are embraced by the book, which provides a vast array of factual information, ideas, concepts, and methods related to the theory and practice of physical science.

The editors have taken particular care to ensure that, even at the date of publication, the text has kept up with progress so far as this is possible, although they have recognized that 'a handbook cannot be completely current with journal literature' and perforce accepted that inescapable handicap. It is, however, not a severe one as fortunate possessors of the book will see for themselves.

McGraw-Hill have published many books of high standard and this is one of the very best. It is the kind of book that should be available to all physicists whatever may be their special interest, although we imagine the (no doubt unavoidable) high price will probably confine sales largely to the libraries in educational, industrial, and research establishments. None the less, the book remains very good value indeed for money and it can be highly recommended.

S. AUSTEN STIGANT

Year Books

Wireless and Electrical Trader Year Book. $8\frac{1}{2} \times 5\frac{3}{4}$ *in* (216 × 146 *mm*). *Pp* 416. (*London: Trader Publishing Co Ltd*, 1959.) Price 12s 6d net.

This hardy annual has several new features which include a list of all the domestic appliances, accessories, radio and TV receivers introduced during 1958. There is also an index of standard stereosonic and single-channel tape records. It contains all the previous information given in earlier editions, and has been brought up-to-date where necessary.

The Engineer's Buyers Guide. $8\frac{5}{8} \times 5\frac{5}{8}$ *in* (219 × 143 *mm*). *Pp* 960. (*London: Morgan Bros (Publishers) Ltd.*) Price 7s 6d net.

This guide contains some 2500 classified headings of engineering products together with the names and addresses of 1500 firms. There are useful sections giving details of associations, institutions, and societies connected with the engineering industry.

The Electrical Trades Directory. 9 × 6 *in* (229 × 152 *mm*). *Pp* 1644. (*London: Benn Brothers Ltd*, 1959.) Price 63s net.

This is one of the most useful and comprehensive reference books of the electrical industry. It contains names and addresses of manufacturers, contractors, wholesalers, and distributors, each arranged in different sections. Other sections contain information of electricity and traction undertakings, institutions, and associations. A Buyer's Guide of 2500 headings and a large index of trade names complete the volume.

Tait's Electrical Directory of Australia & New Zealand. $8\frac{1}{4} \times 6$ *in* (223 × 153 *mm*). *Pp* 410. (*Melbourne: Tait Publishing Co Pty Ltd.*) Price £3 (Australian).

This is the recognized handbook of the Australian and New Zealand electrical supply industry. It contains names and addresses, the chief engineer, supply details and tariffs of all electricity undertakings in Australasia, including plant details of manufacturers and mines generating their own electricity.

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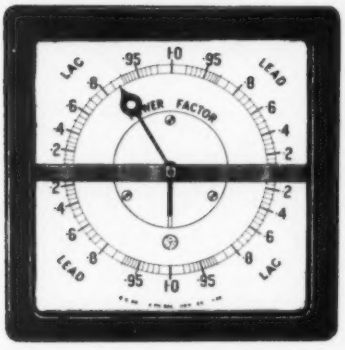
NALDERS INSTRUMENTS



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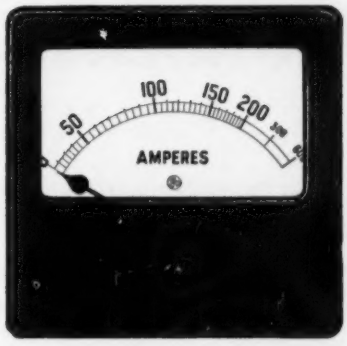

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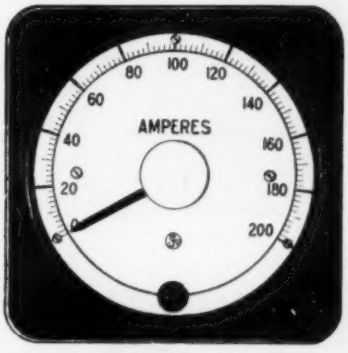

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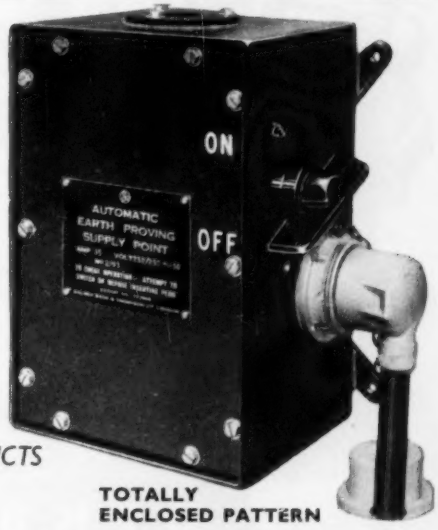

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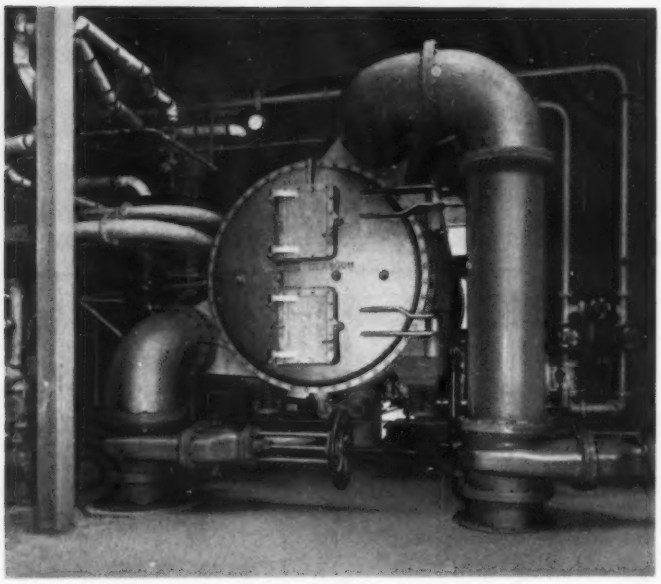

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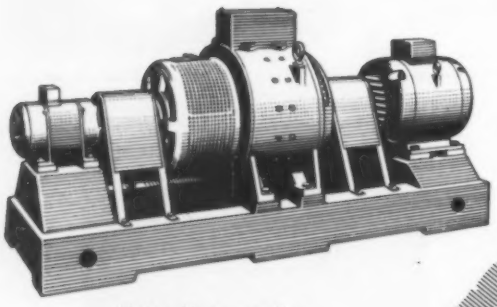

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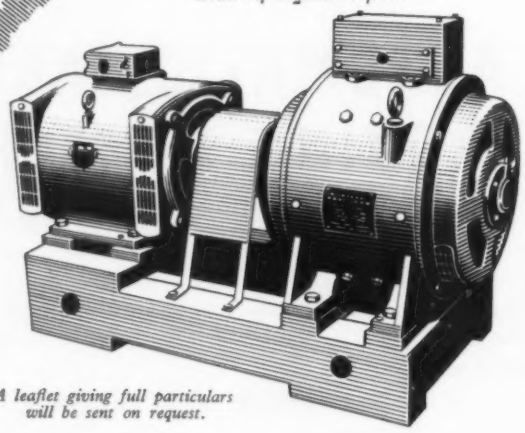

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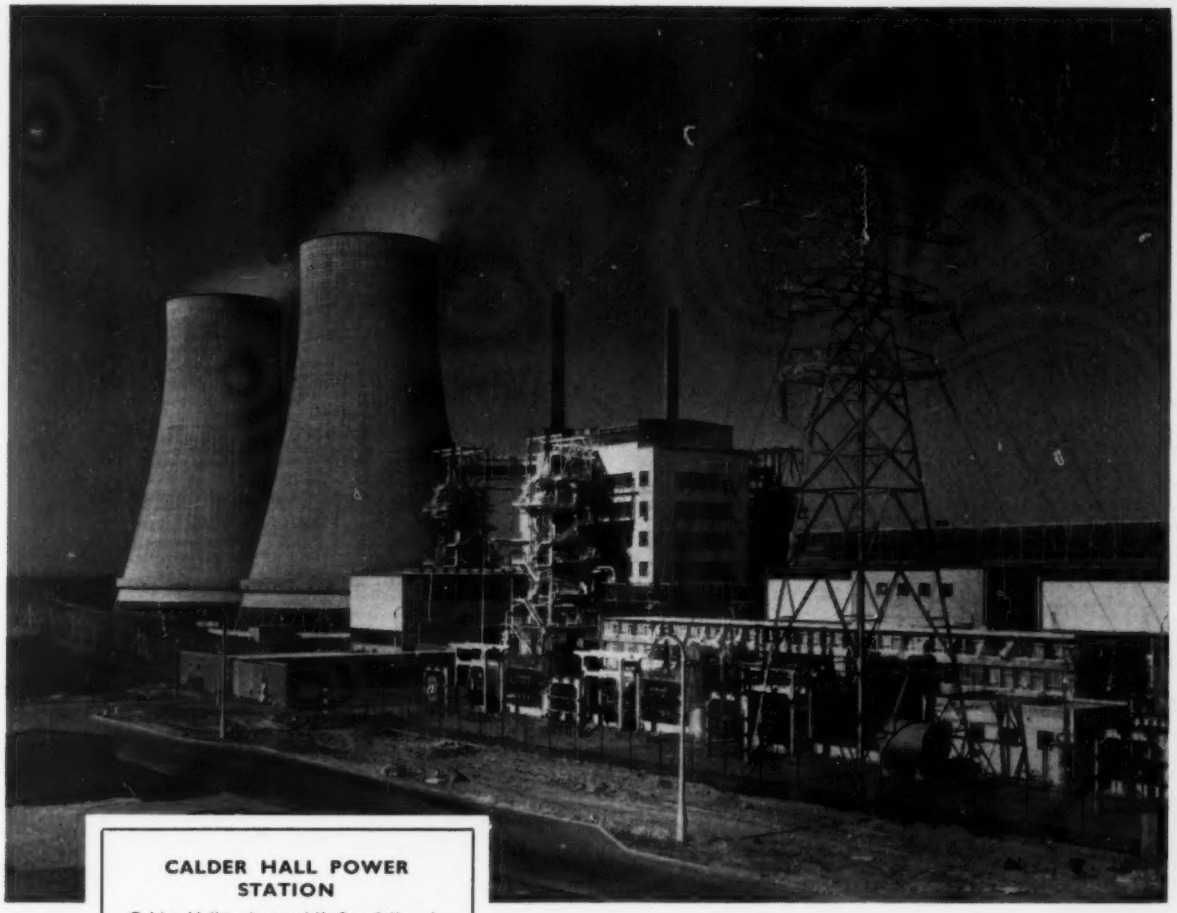

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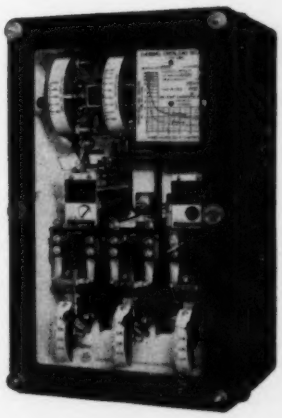

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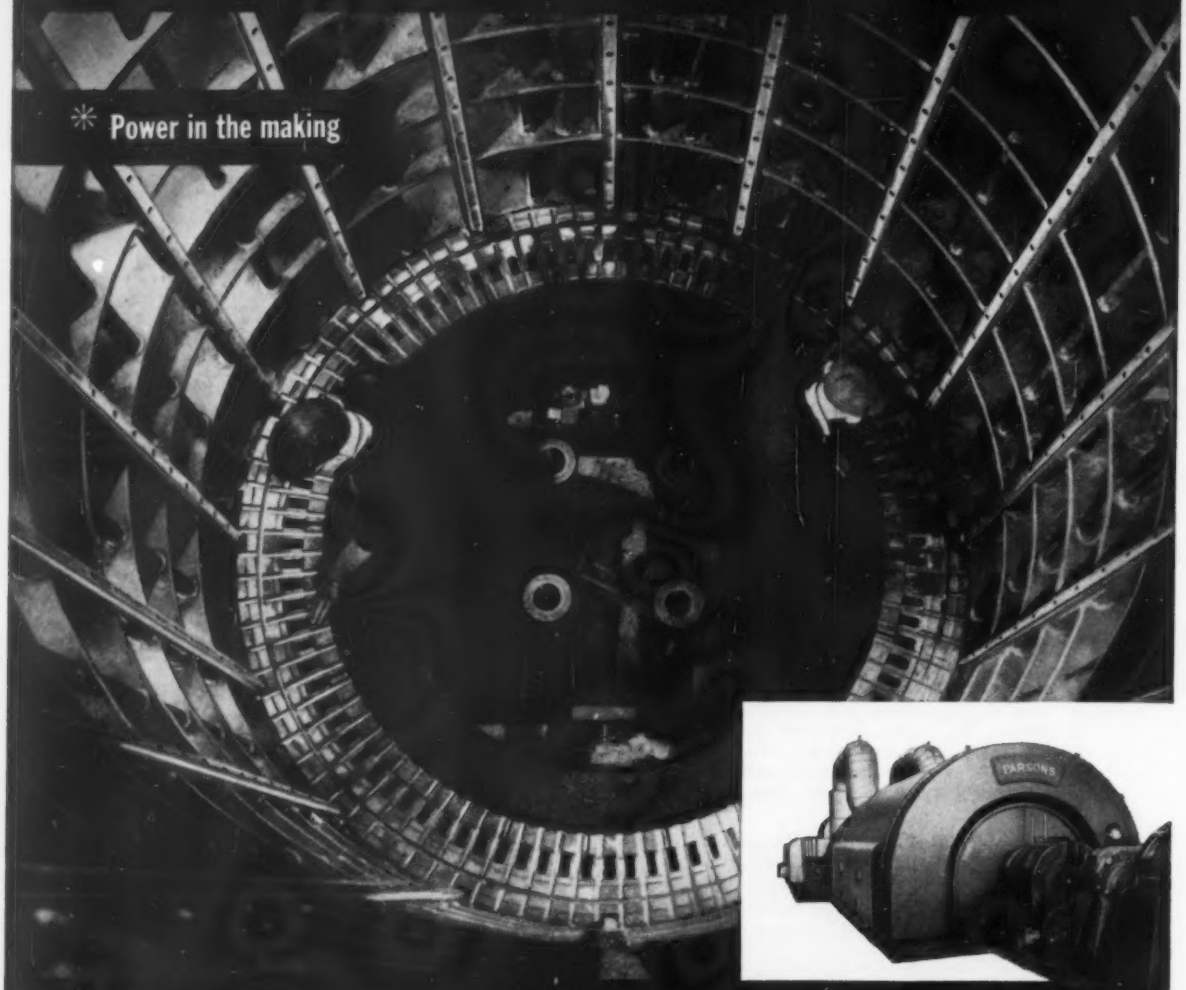

Fitting core end plate to the generator stator.

Inset: A typical completed 120 MW set.

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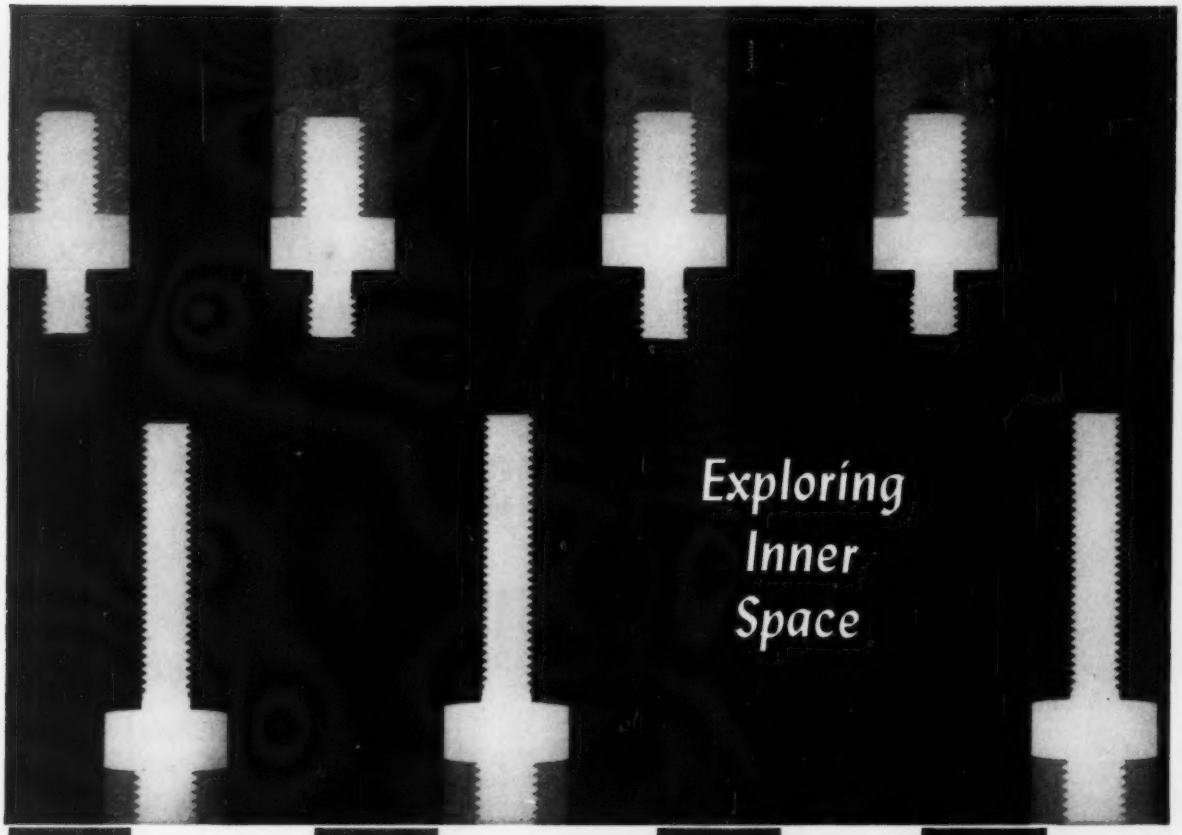

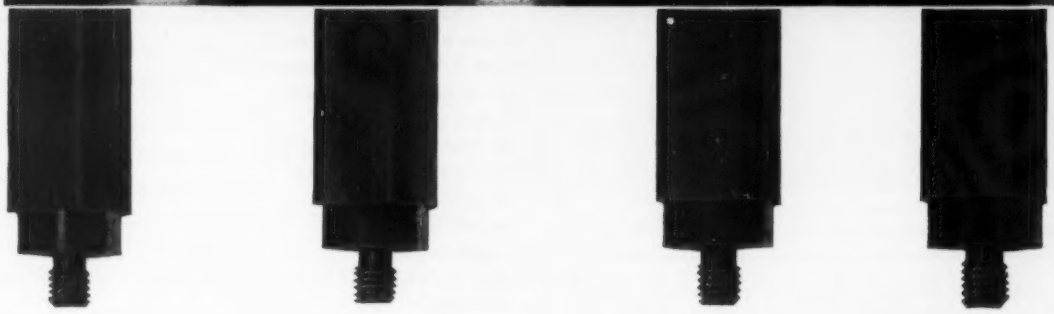

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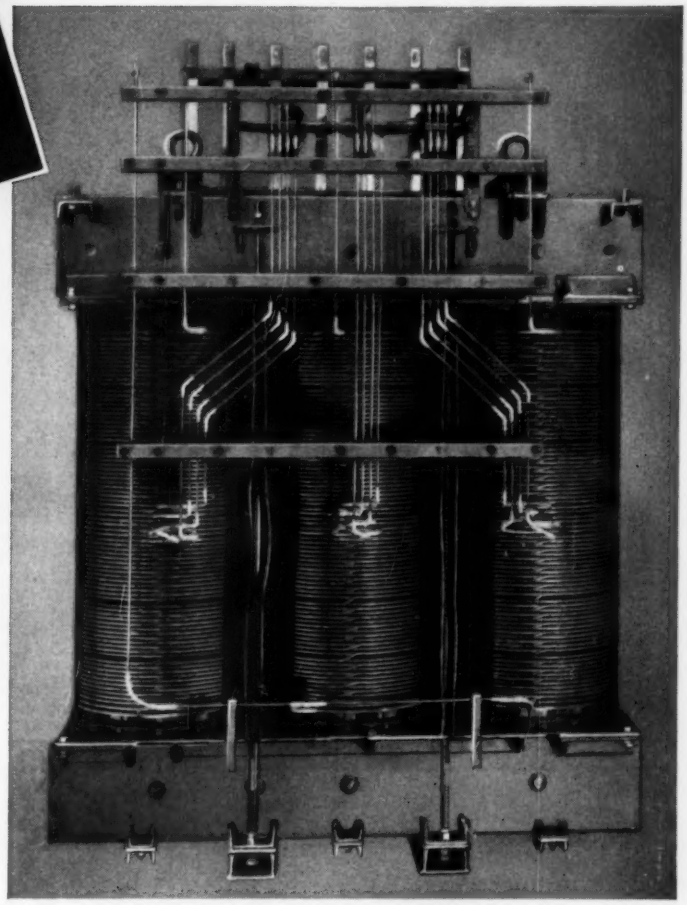

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LLANDARCY OIL REFINERY

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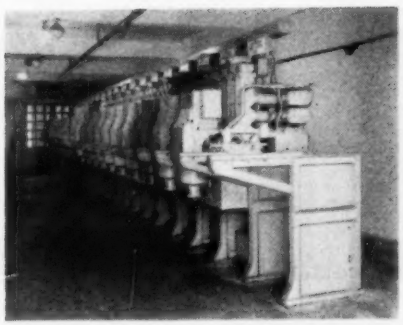

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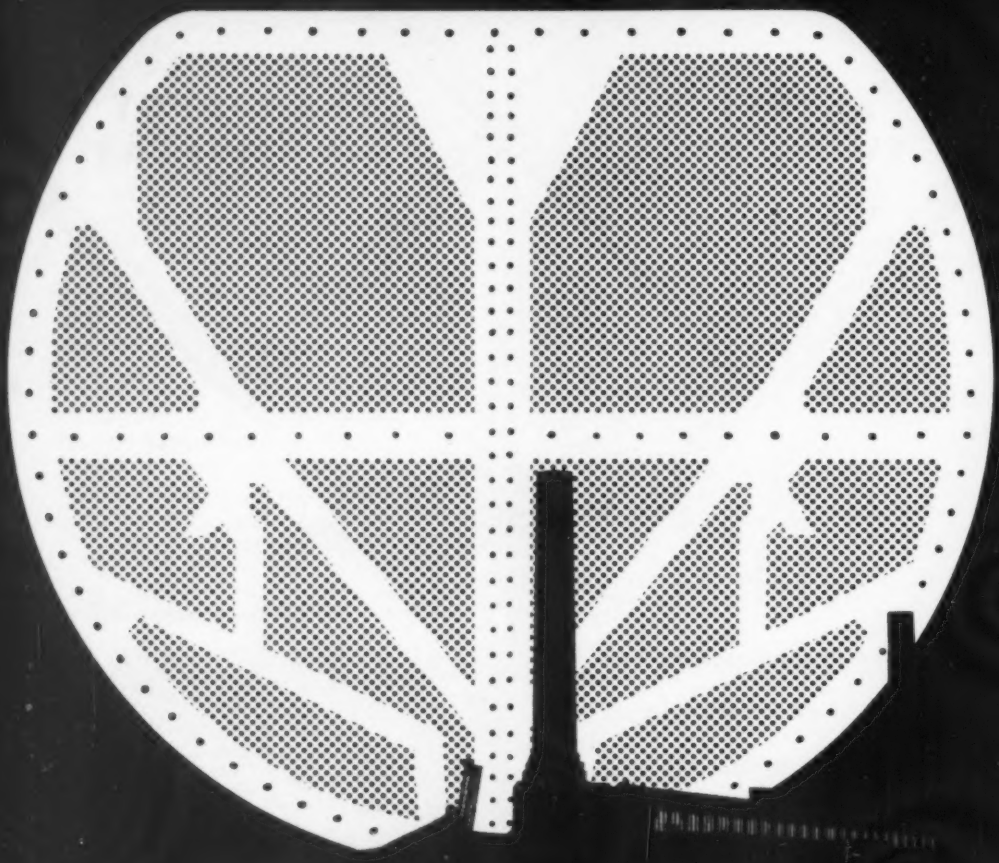

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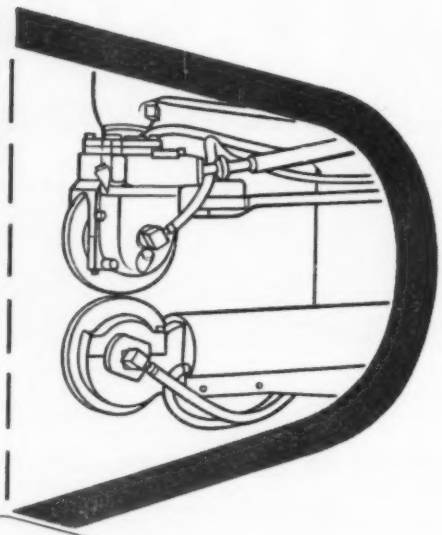

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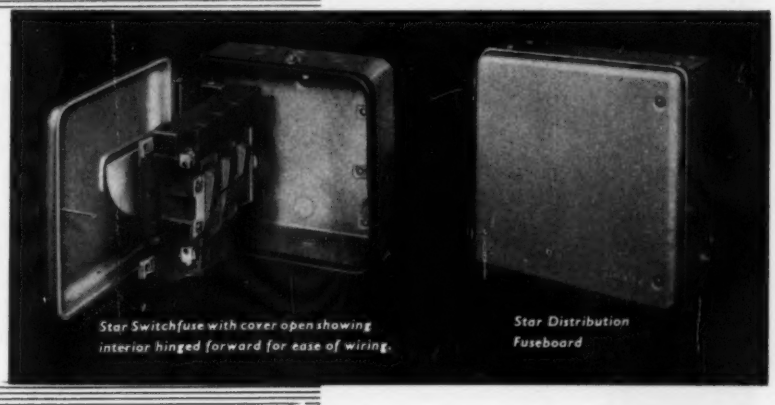

Star Switchfuse with cover open showing interior hinged forward for ease of wiring.

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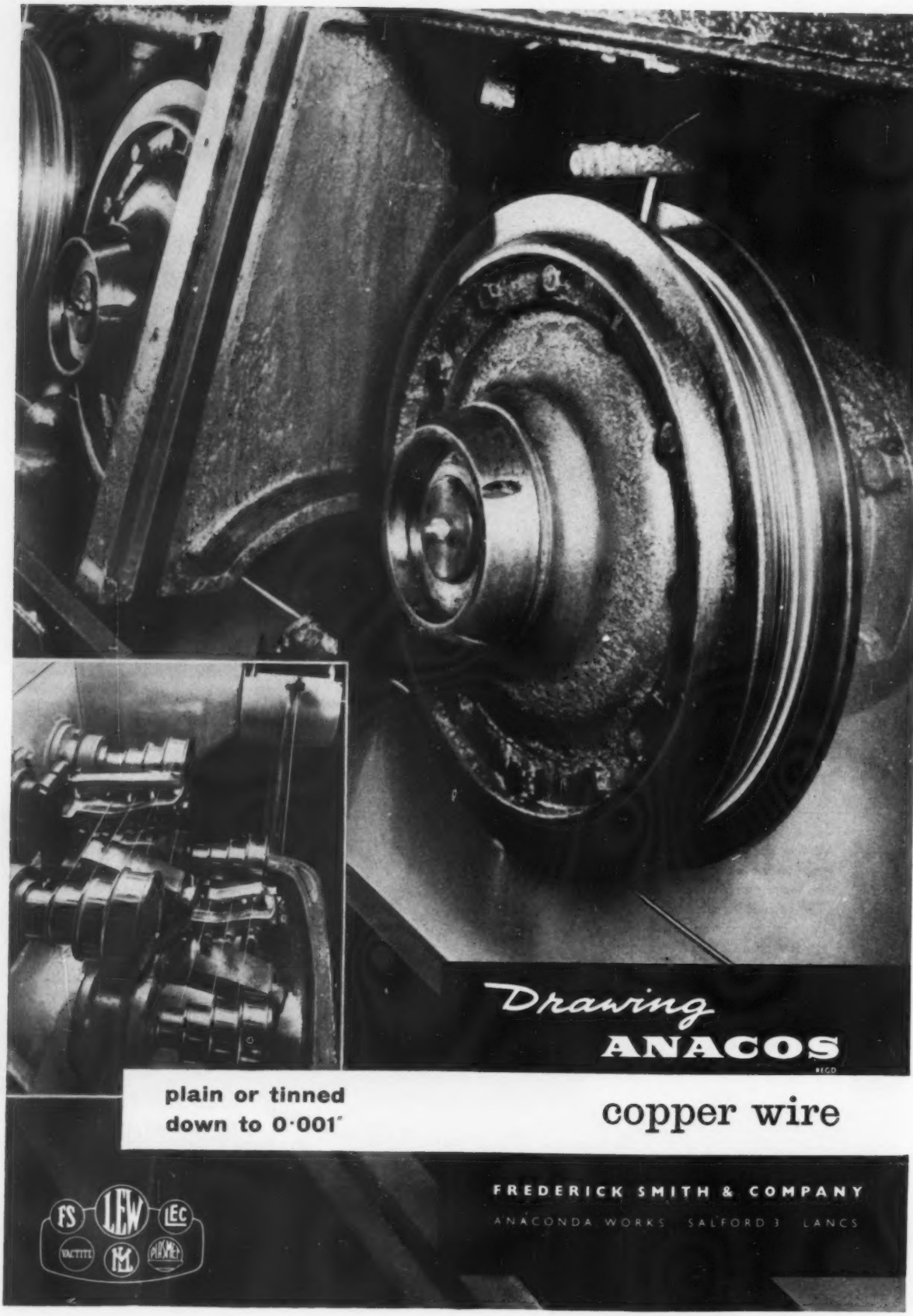
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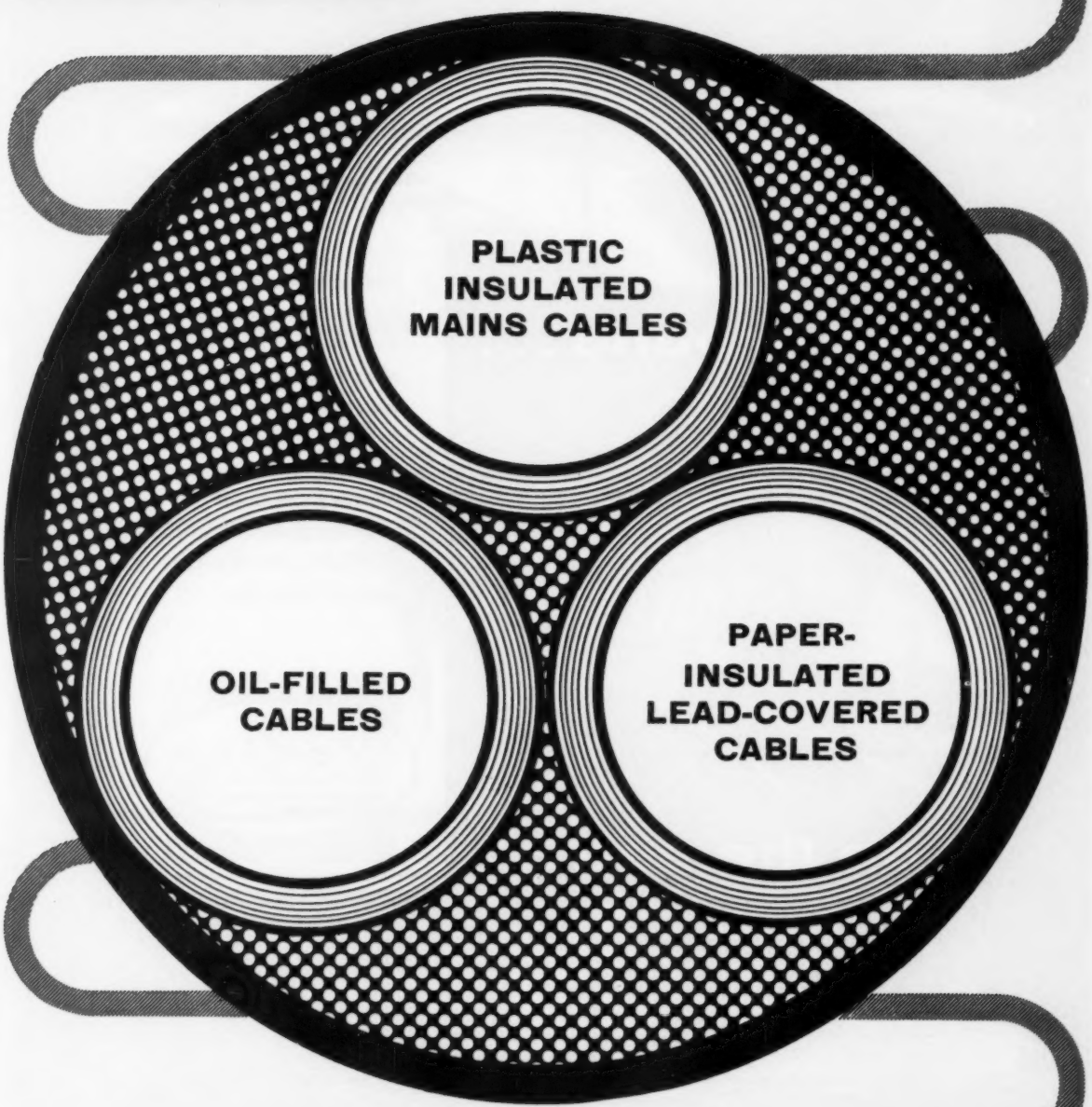

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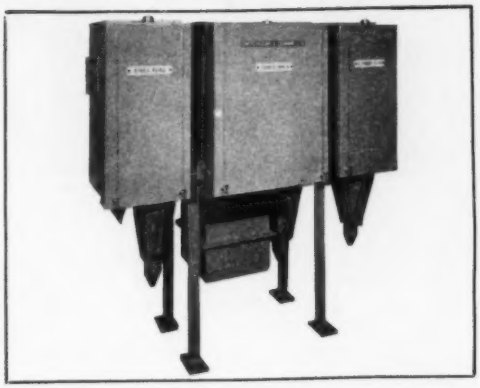

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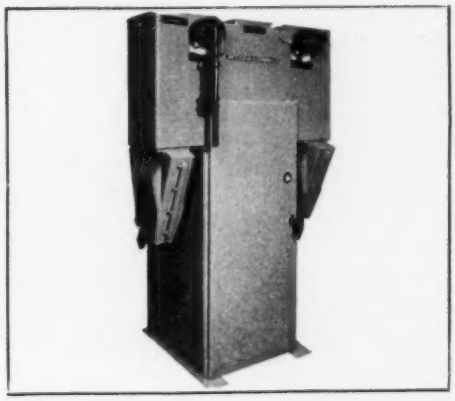

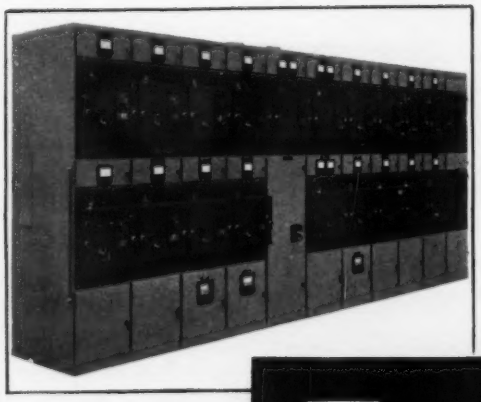

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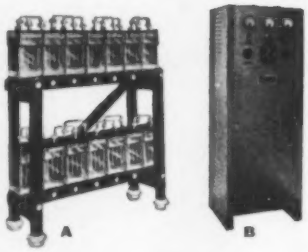
Please send for Publications Nos. 90, 91 and 92, which give full details of the standard range of 'Safetylyte' Equipment. *Comprehensive specifications for special emergency lighting installations prepared without obligation.*



A *Double-tier stand holding a typical battery of 14 Tudor sealed-type cells as used with 'Safetylyte' emergency lighting equipment.*

B *'Safetylyte' Major charging and control cubicle.*

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EMERGENCY LIGHTING EQUIPMENT

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METAL RECTIFIER ENGINEERING

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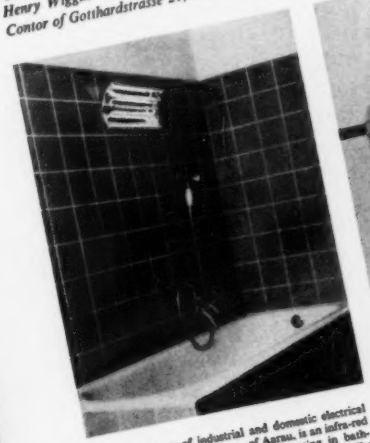
Taking a leaf out of the Wiggin book

Swiss domestic electrical equipment

Switzerland is a small and highly industrialized country without any indigenous coal or oil, but endowed with abundant water power. Electricity is thus the chief source of energy, with the result that a large and thriving electrical industry has grown up. By virtue of their consistent success in making and exporting a wide range of quality products, the Swiss people enjoy excellent living standards and make wide use in their homes of electrical equipment designed to promote domestic comfort. Although this equipment is Swiss made, it commonly contains specialized materials imported from Great Britain. In the following pages are shown a few of the many Swiss domestic appliances which embody heating elements of 'Brightray' nickel-chromium alloys produced by Henry Wiggin and Company Limited and distributed in Switzerland by their agents, Nickel-Contor of Gotthardstrasse 21, Zurich 2/22.



Among the range of industrial and domestic electrical equipment made by MAXIM A.G., of Aarau, is an infra-red radiation heater designed for wall mounting in bathrooms, kitchens, children's nurseries and so forth. The reflector is a bright aluminium pressing and the elements are of the tubular sheathed type with spirals of Brightray C resistance wire encased in mineral insulation within the sheath. Rated at 1 kW, the heater can be supplied for operation at various voltages up to 380 and measures about 14 in. × 6¼ in.

Water distillation units of both the semi- and fully-automatic type with outputs from 2 to 20 litres per hour are included in the products of TROOTHEARE A.G., of Biasca. The fully-automatic model includes a storage tank of 100–300 litres capacity, containing a liquid level measuring device coupled to the distillation unit; as distilled water is drawn off, the storage tank is automatically replenished. Sheathed heating elements with Brightray C wire spirals are standard, with outputs from 1 to 6 kW and for voltages of either 220 or 380.

22

BRIGHTRAY 'C'

Articles dealing with engineering developments in many fields appear regularly in 'Wiggin Nickel Alloys'. Topics discussed here can spark off ideas for a new approach to your own problems of extreme temperatures, corrosion, oxidation, mechanical stress, or electrical resistance.

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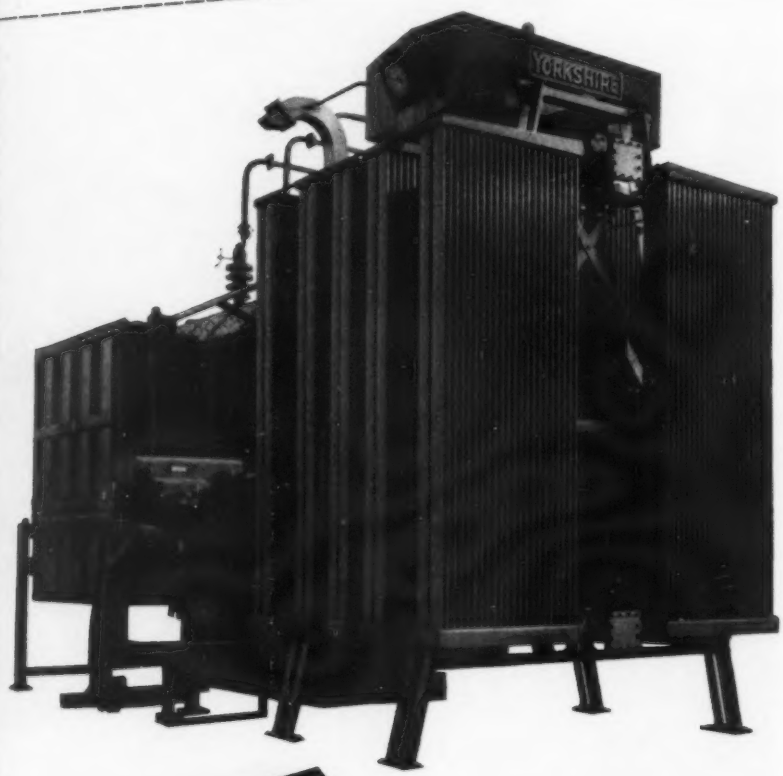

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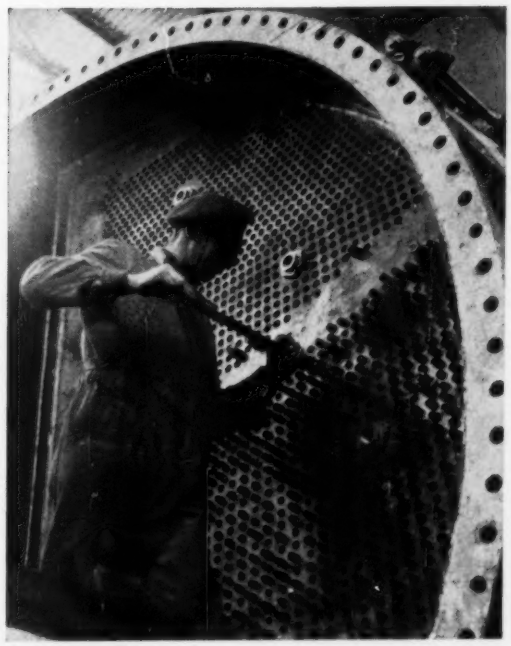

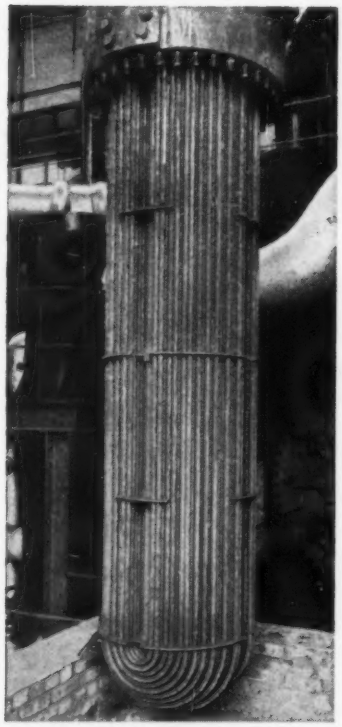

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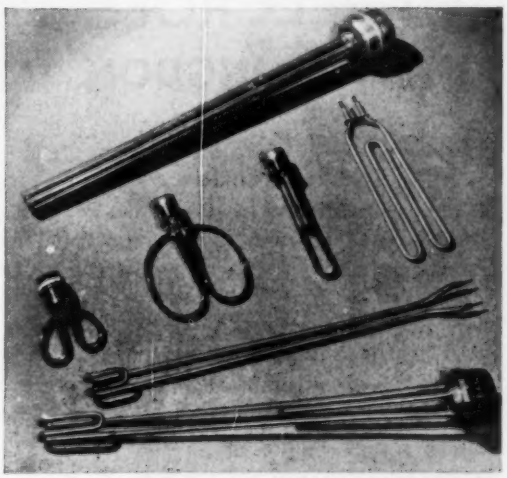

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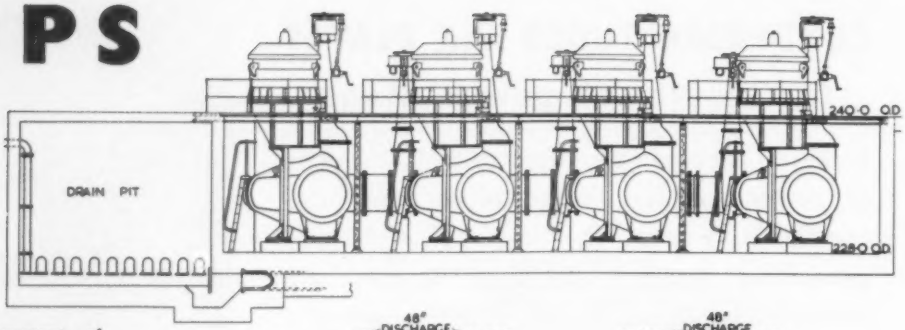
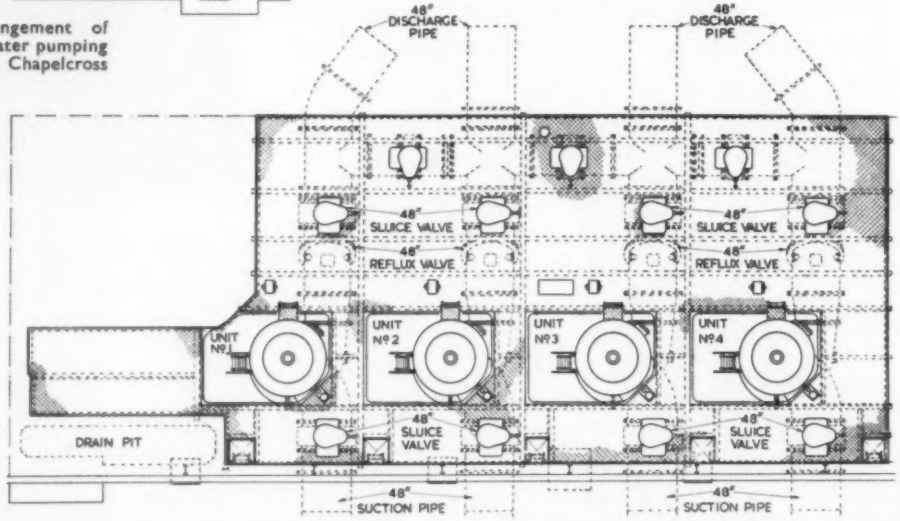
ALLEN CIRCULATING-WATER PUMPS



Installation arrangement of the circulating-water pumping units at the Chapelcross Power Station.



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Consulting Engineers: MERZ and McLELLAN

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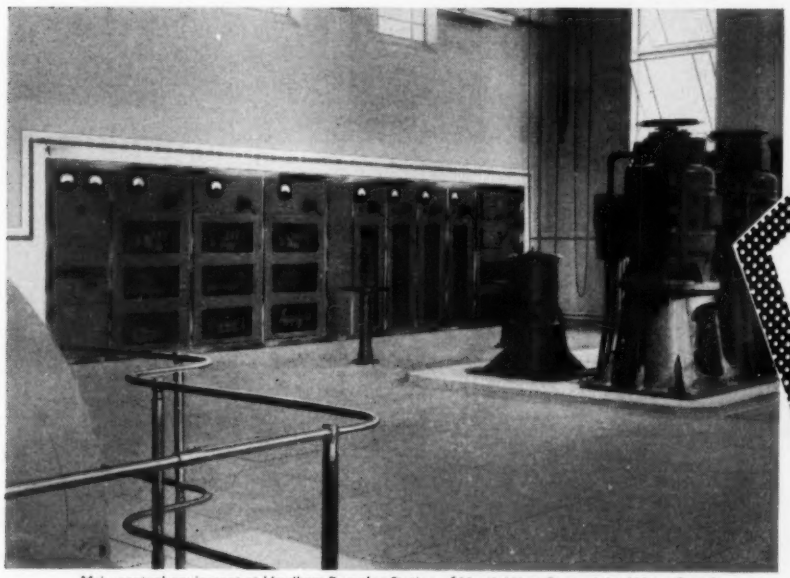

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North Point Power Station

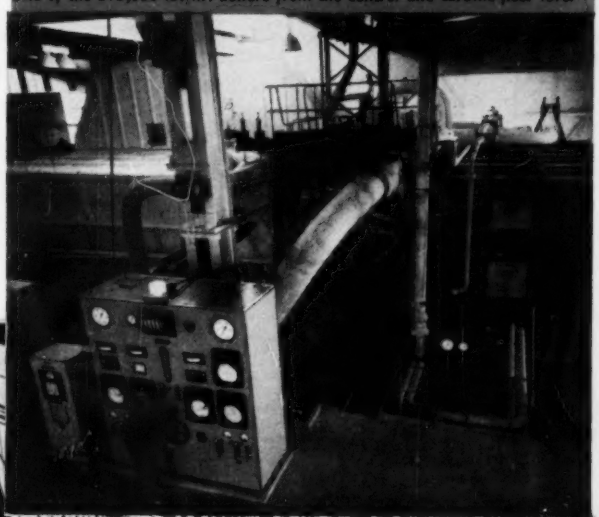
HONG KONG

The North Point 'A' power station of the Hong Kong Electric Company Ltd. is equipped with 22 boilers all supplied by the BABCOCK organization, the last three of these being oil-fired Integral Furnace units of 150,000 and 200,000 lb./hr. capacity, with steam conditions of 425 lb./sq. in. and 775°F.

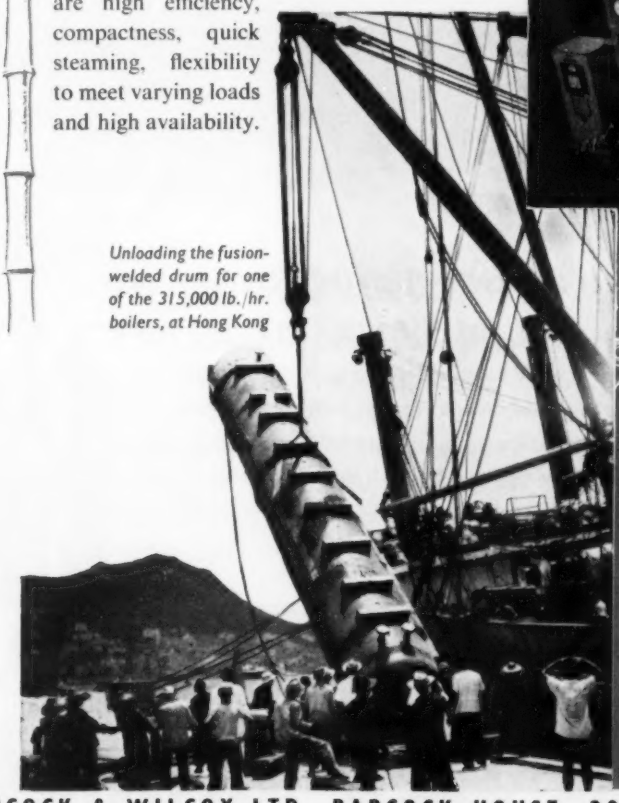
The new and adjacent North Point 'B' station will have a capacity of 150 MW, and the first three boilers installed are again BABCOCK oil-fired Type FH units, of larger capacity, i.e. 315,000 lb./hr. at 625 lb./sq. in., 865°F.

The selection of BABCOCK Integral Furnace boilers for the new station, following experience with similar units at North Point 'A', endorses the good performance of this type, the outstanding characteristics of which are high efficiency, compactness, quick steaming, flexibility to meet varying loads and high availability.

Aerial view of the stations, with North Point 'B' in the foreground



One of the 315,000 lb./hr. boilers from the control and turbine-floor level



Unloading the fusion-welded drum for one of the 315,000 lb./hr. boilers, at Hong Kong

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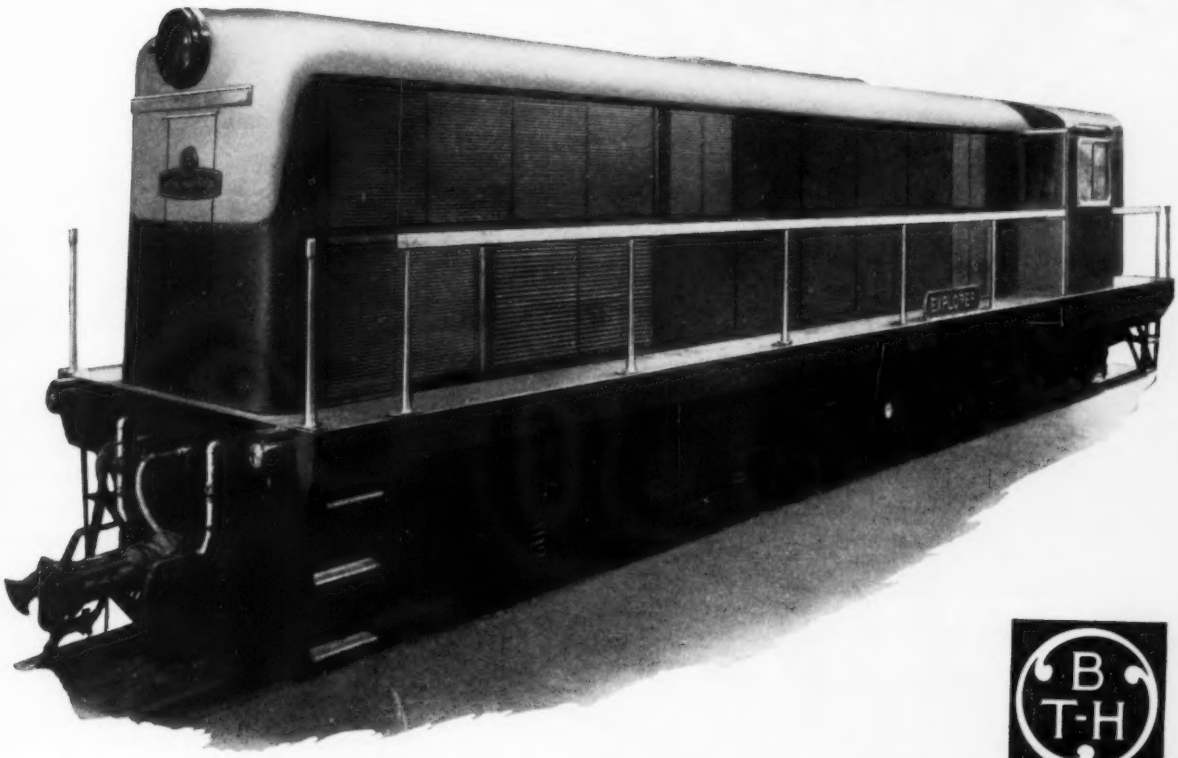

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This is an 1100 h.p. diesel-electric locomotive specially designed to give outstanding service where the going is hard. It is particularly suitable for overseas railways operating in difficult terrain. Maximum power is sustained at sea level in an ambient temperature of 120°F, or up to an altitude of 4,000 ft. at an ambient of 85°F.

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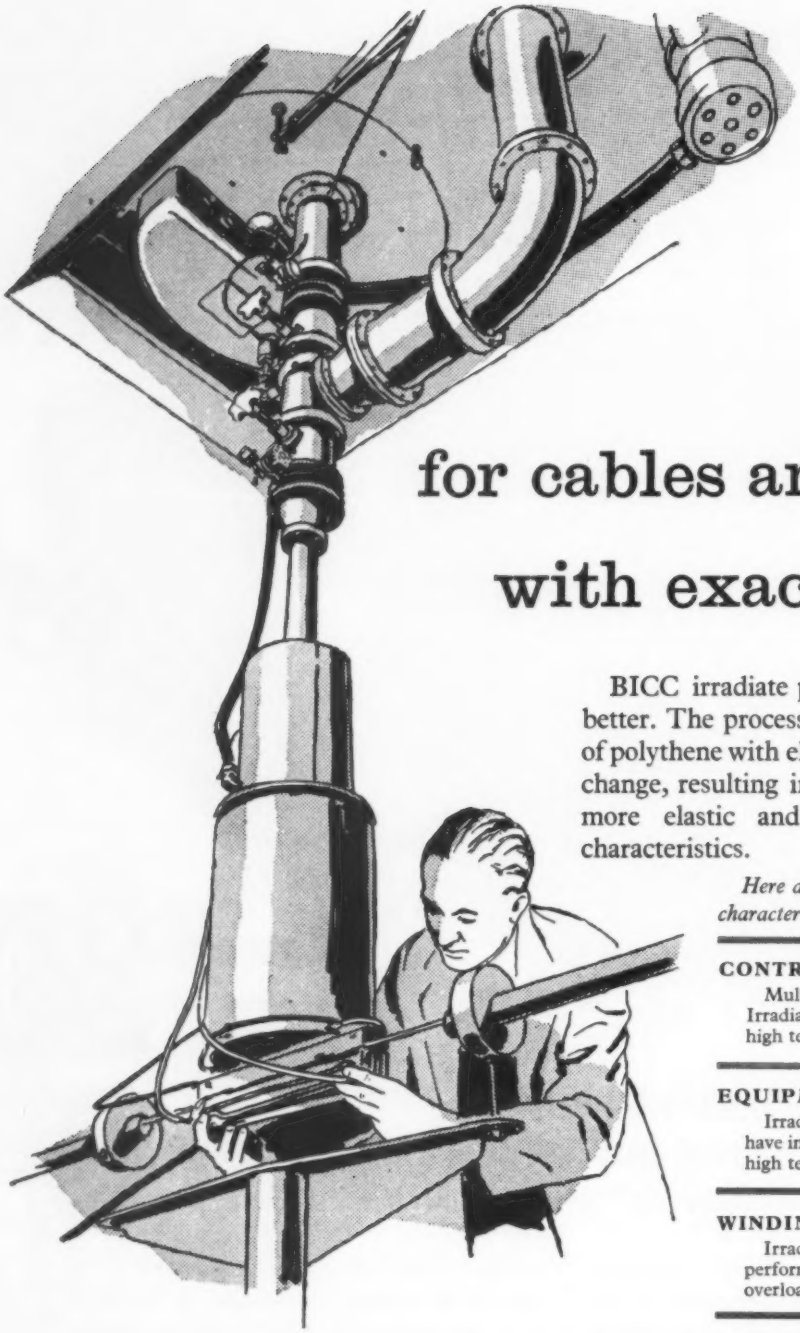

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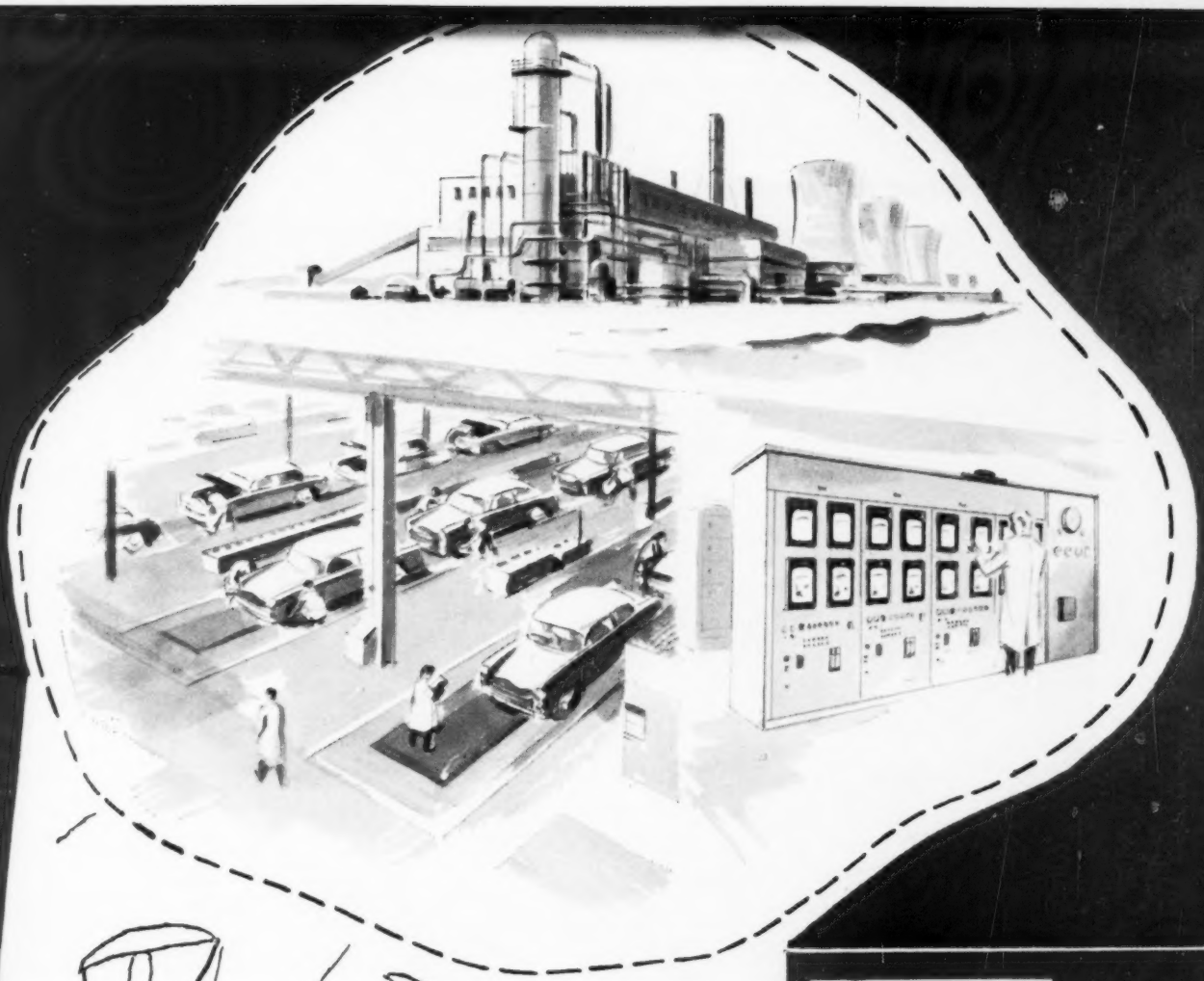

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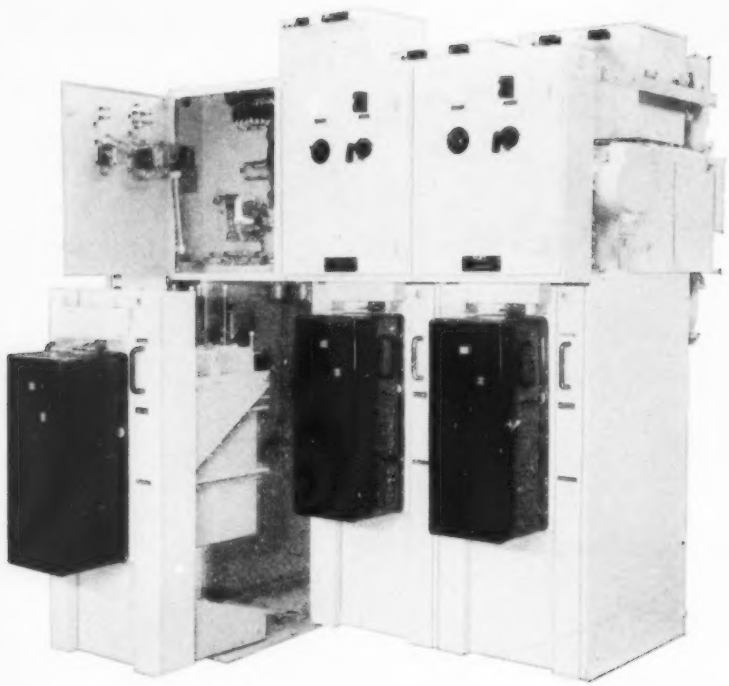

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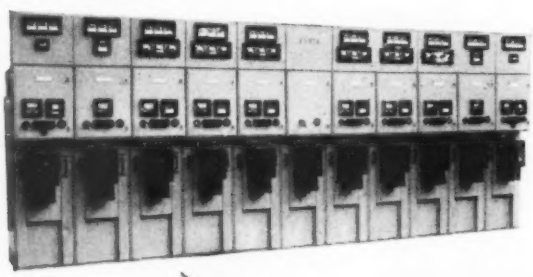

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S5.

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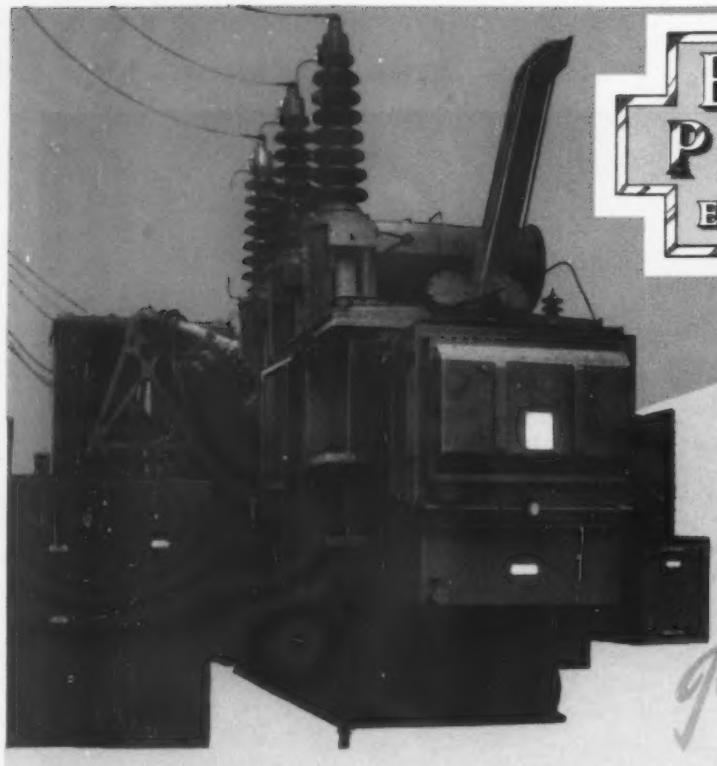

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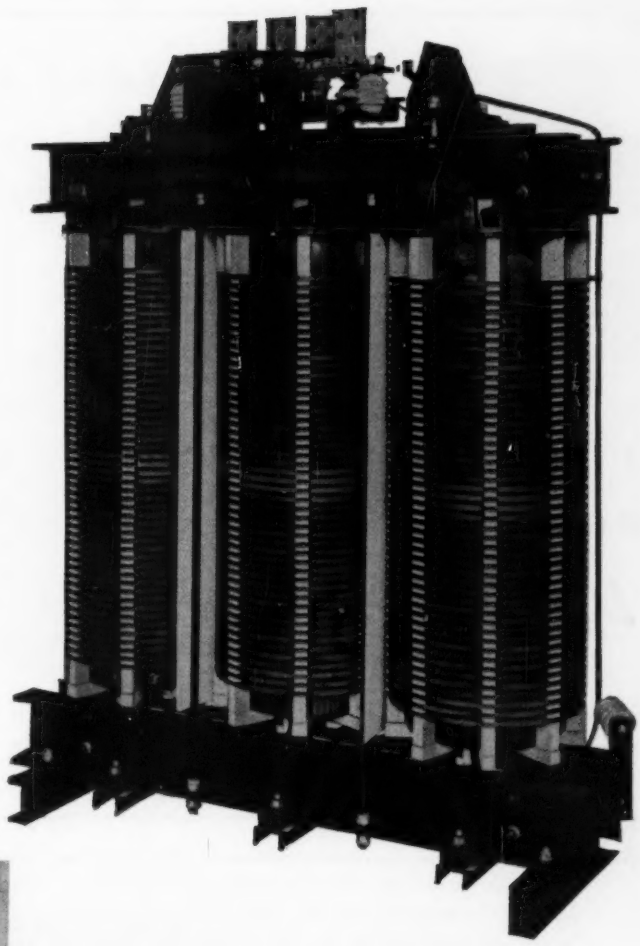

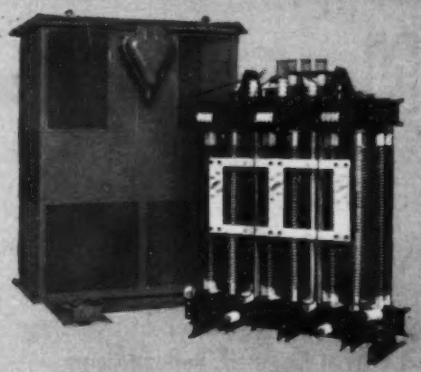

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For any installations where fire risk is high or consequential loss would be considerable, the introduction of the dry type air-cooled Class 'C' Transformer marks another major step in security.

Illustrated is a 1,000kVA, 3 phase, 50 cycles, 11,000/433 volts Bryce Low Loss Distribution Transformer using Class 'C' insulation.

BRYCE ELECTRIC CONSTRUCTION CO. LTD.

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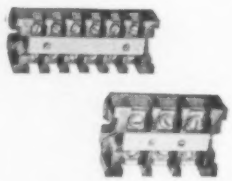
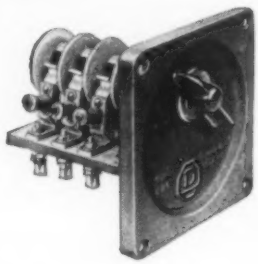
In association with Hackbridge Cable Co. Ltd.

Broadway/bec 6

Limit Switches (Type C32L 810.1) Plunger pattern with roller on end. Roller can be moved through 90 degrees and the switch can be altered from N.O. to N.C. on site.



Terminal Blocks (Type J96). Clamp type terminals, White marker strip, generous clearances between phases and to earth. Sizes available—15-amp. 550-volt. 3, 4, and 6-way. 30-amp. 550-volt. 3 and 4-way.



Flush-mounting T.P. Isolating Switch (Type C95) for building-in Machine Tools, etc. 30-amp. 550-volt.

A.C. Power Relays (Type A 11). Available 2, 4, or 8-pole (with one or two coil circuit change-over contacts), fine silver double-break main contacts rated at 10-amp. 550-volt. Any pole can be N.O. or N.C.

Illustrated is a 4-pole enclosed relay.

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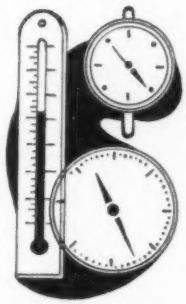

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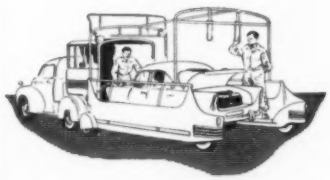

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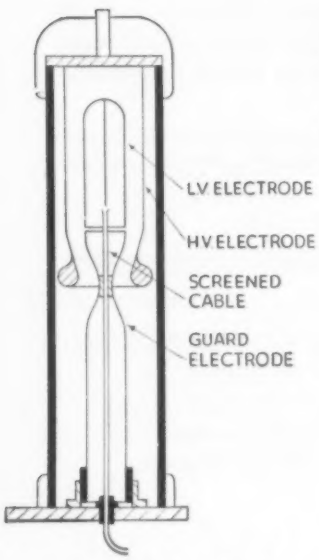

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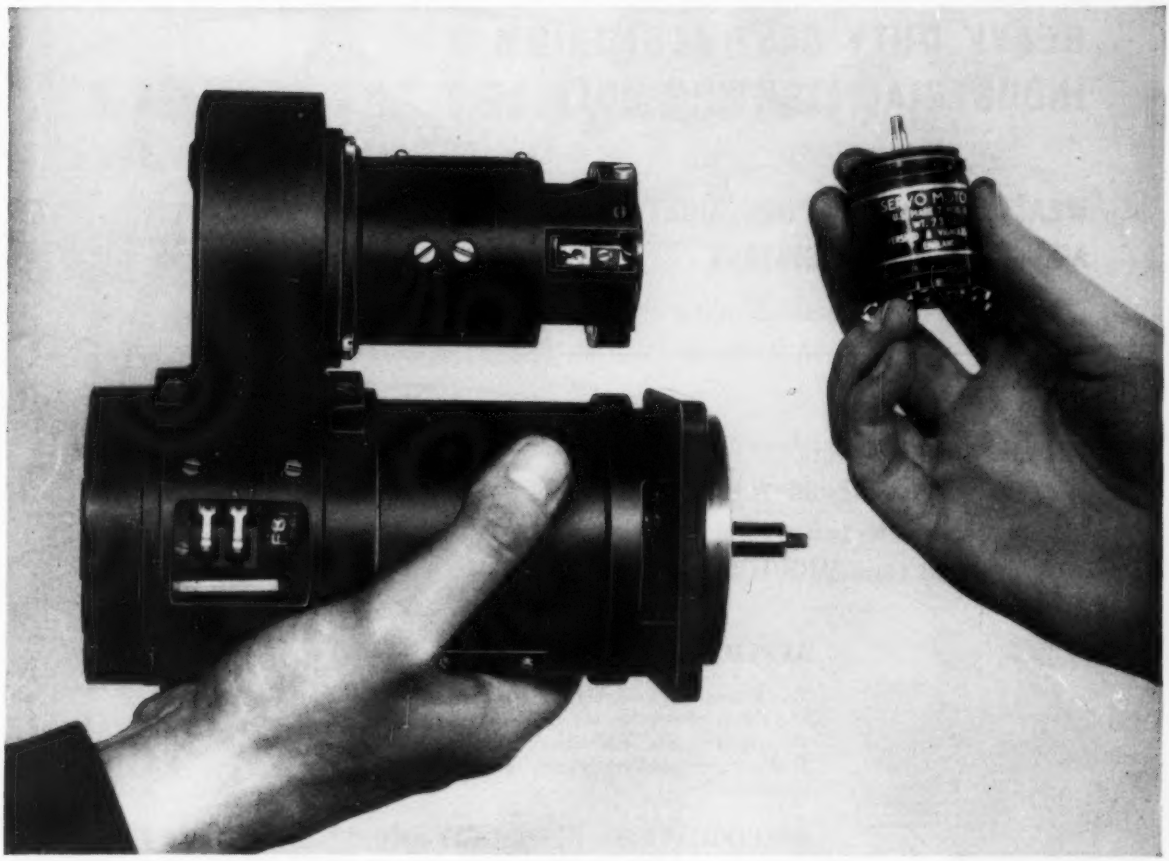

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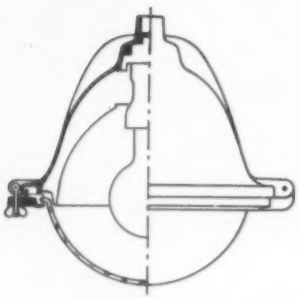

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The Fittings are especially designed for use where high angles of light are essential and where protection is required against weather or corrosive atmospheres. It meets the requirements of a variety of industries amongst which are the following:— Railway marshalling yards, Docks and Harbours, Cargo Loading, Gasworks, Chemical Works, Steelworks.

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The main body of the fitting (finned for heat dissipation) and the glazing ring is constructed from die-cast aluminium alloy L M 6 M, pre-treated from the "Alocrom" process prior to stove enamelling, one coat red oxide primer and two coats of corrosion resistant grey stove enamel.

The internal reflector is of super-purity aluminium sheet anodically treated by the Brytal process.

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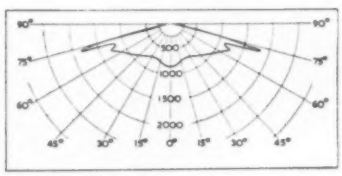
Access to the interior is provided by hinge and swing bolts, the hinge of the floating type permitting equal tension to be exerted on the gasket when the lantern is closed. The locking nuts are made captive on the swing bolts to avoid loss.

All external bolts, nuts and fixings are of stainless steel.



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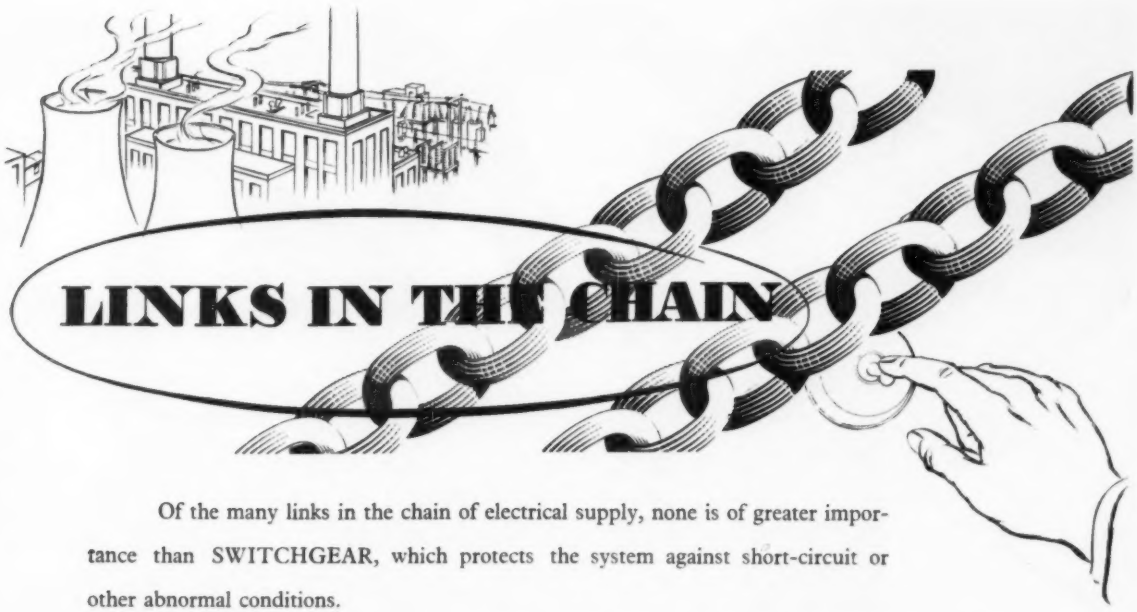
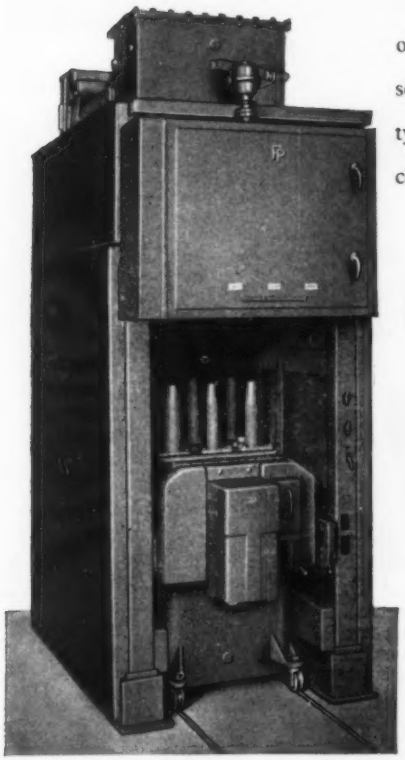
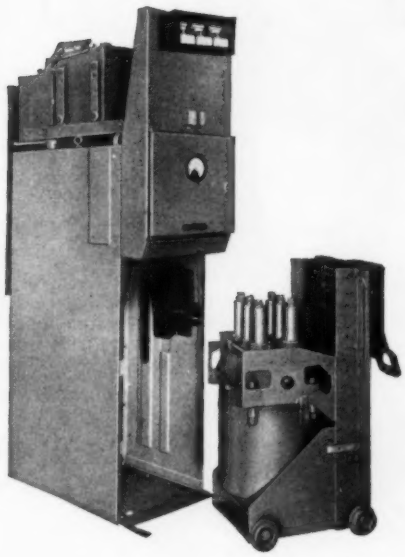


Of the many links in the chain of electrical supply, none is of greater importance than SWITCHGEAR, which protects the system against short-circuit or other abnormal conditions.

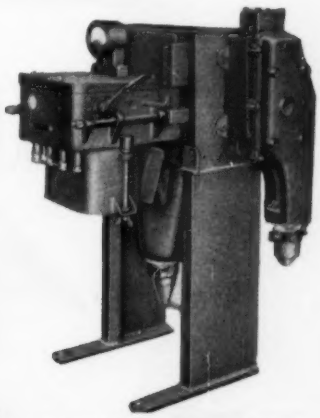
"Ferguson Pailin" have a high reputation for the manufacture of Switchgear of all ratings, from that designed for extra high voltage service within the 'Supergrid', down to medium voltage or industrial type Switchgear which may be found in service in factories and commercial buildings everywhere.



Type VSLP9 Switchgear, rated 1000-MVA breaking capacity at 33-kV.



Type BV Switchgear for 11-kV service up to 250-MVA breaking capacity.



Type K3 pedestal mounted switchgear for service up to 400-A 660-V.

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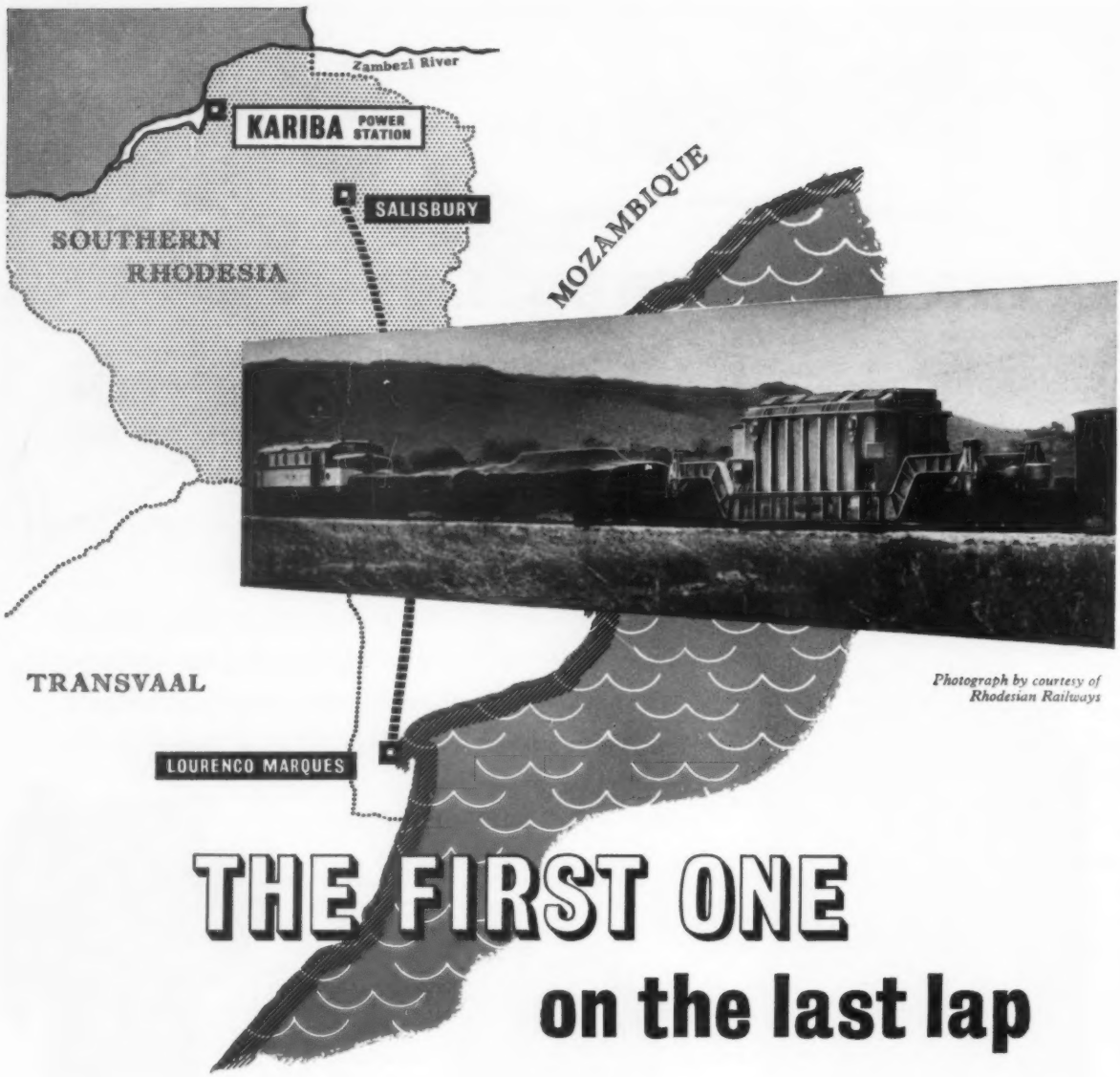

Photograph by courtesy of Rhodesian Railways

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The first 60,000 kVA 330/33 kV 3-phase double wound transformer en route from Lourenco Marques to Salisbury Sub-Station, for the Kariba Hydro-Electric Scheme.

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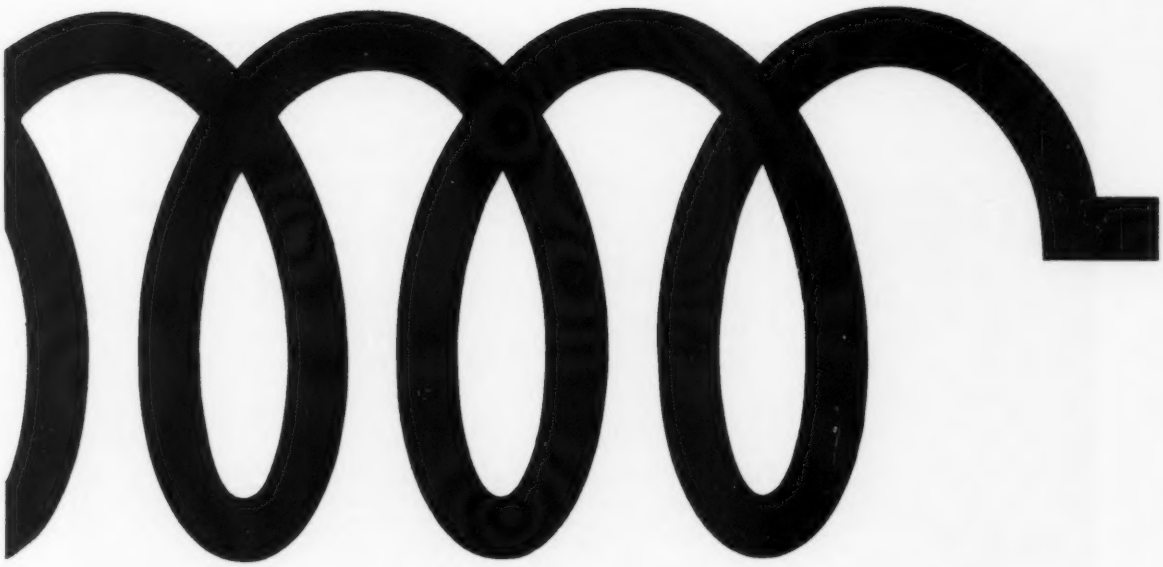
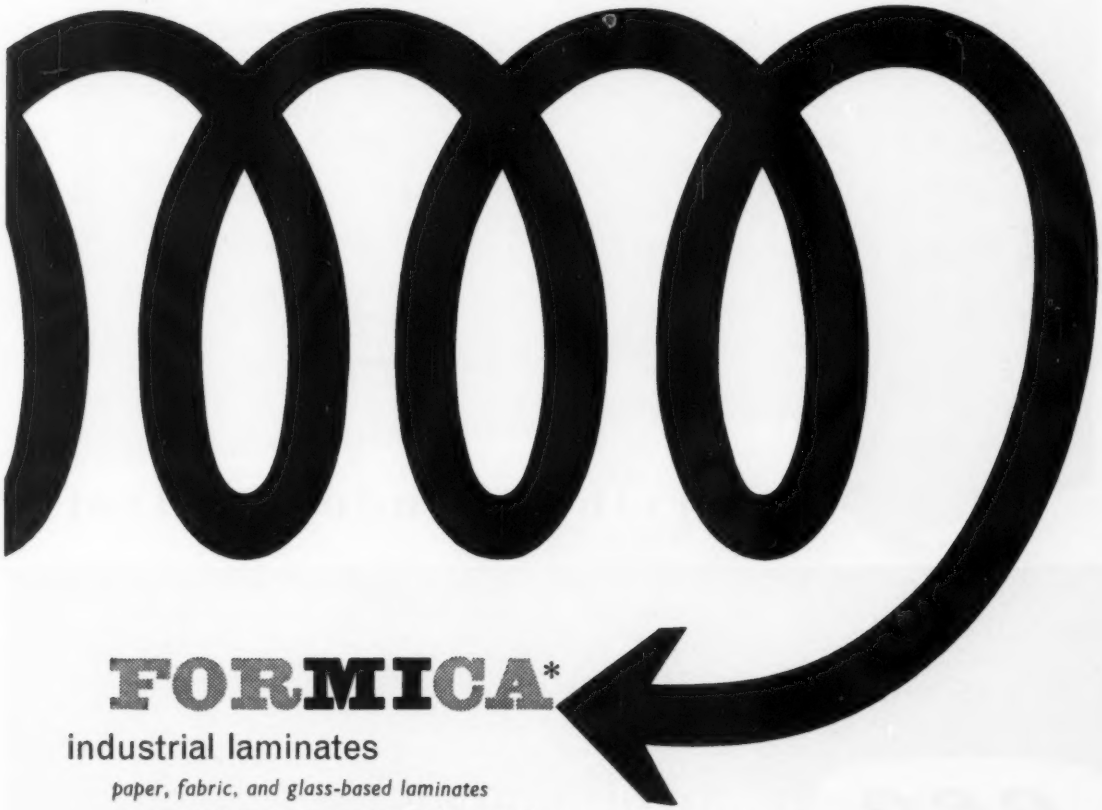


FORMICA for electrical insulation



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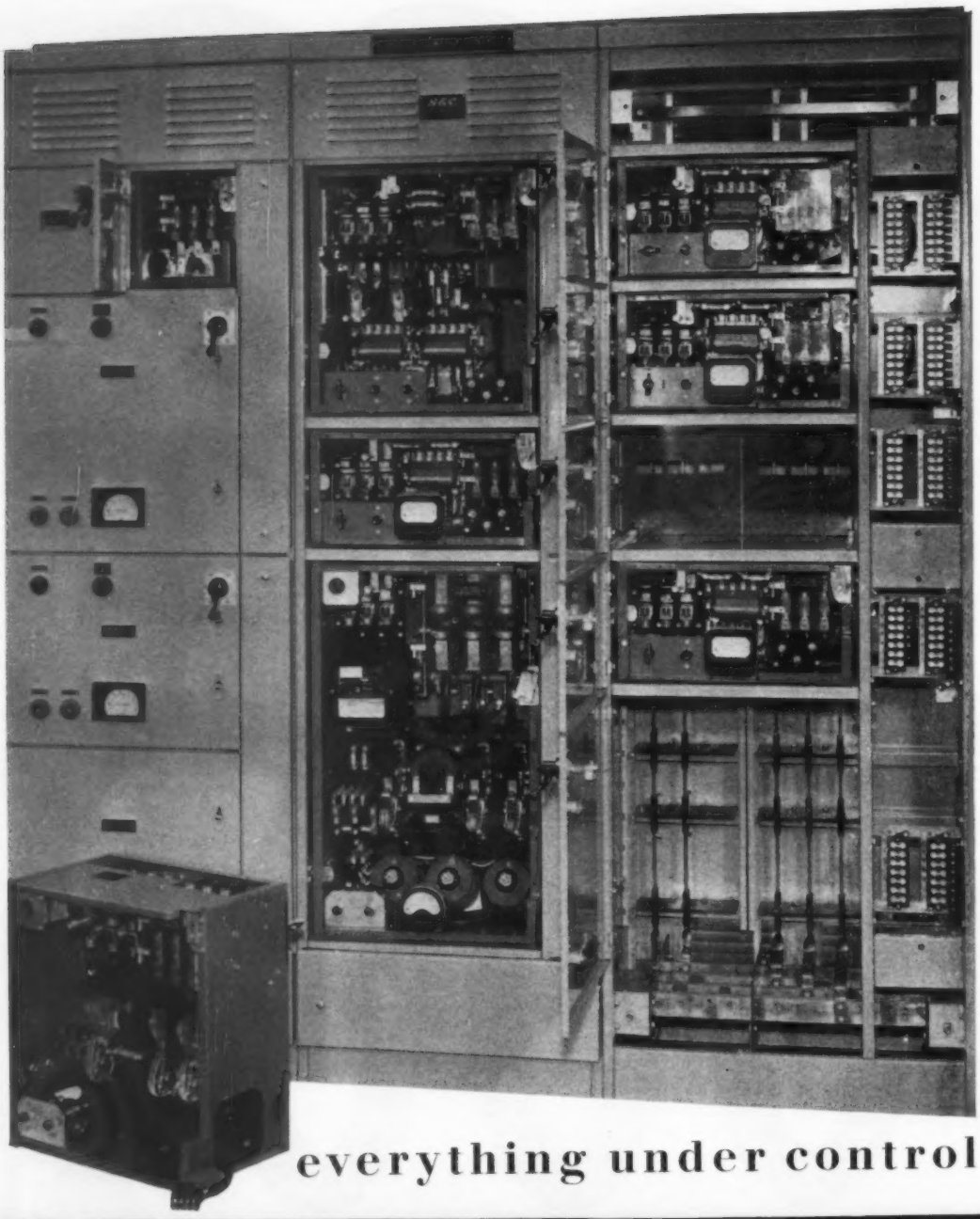

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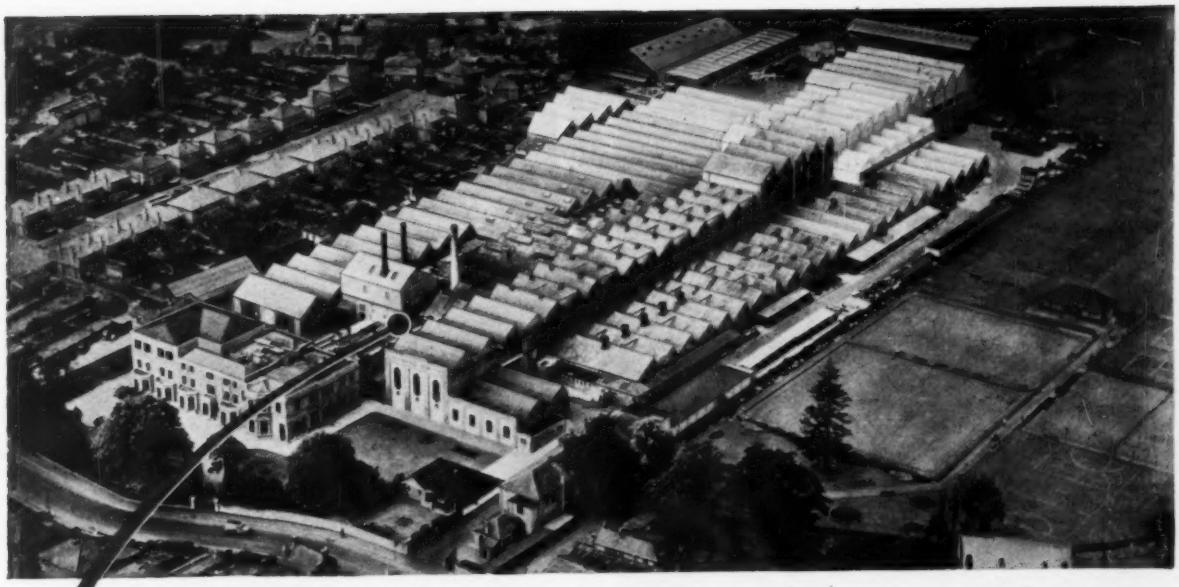

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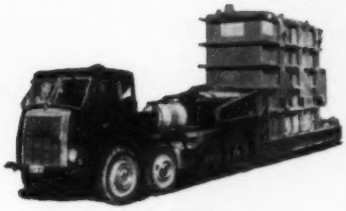

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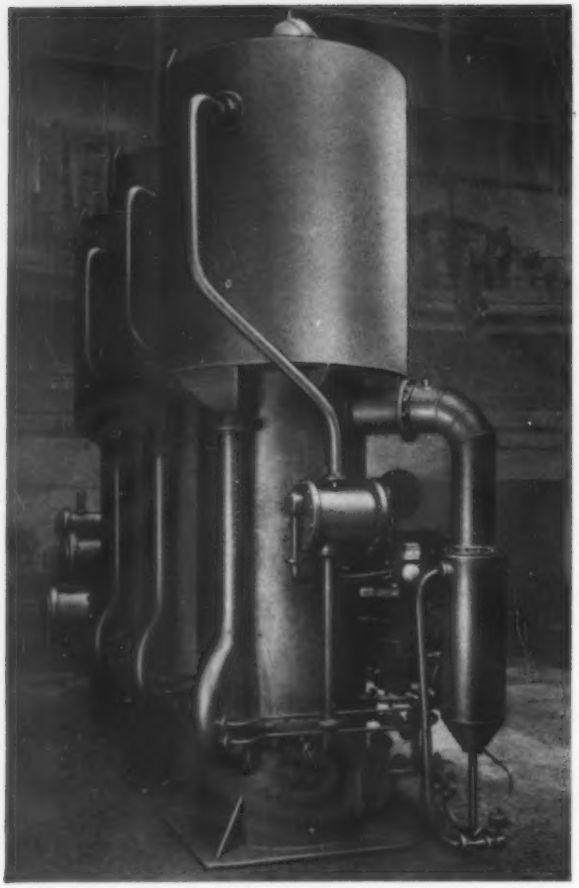

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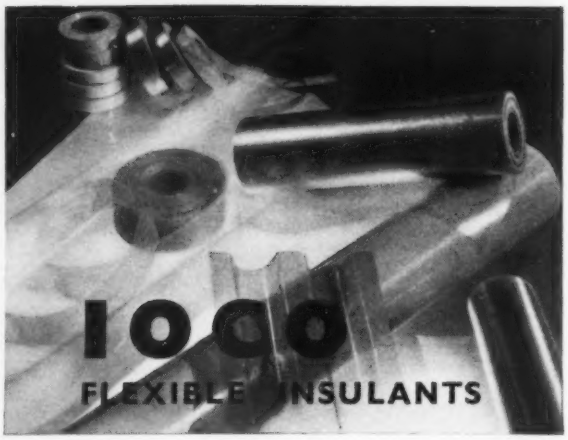

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No tails exposed, no meter lead shield needed—this Service fuse is only 6″ x 1⅞″ x 2¼″ deep yet gives ample room for terminating twin service cables up to .0225 sq. in. Together with the double-pole multi-way connector box it fits snugly below the meter. Most compact of designs for single meter installations, this Henley development is described in our Catalogue 43 which we will gladly send you.

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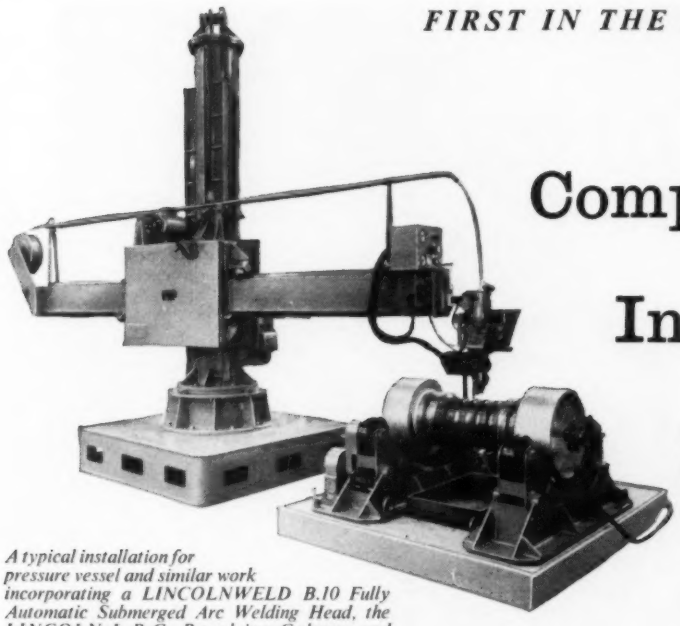

A typical installation for pressure vessel and similar work incorporating a LINCOLNWELD B.10 Fully Automatic Submerged Arc Welding Head, the LINCOLN L.R.C. Revolving Column and Travelling Boom and LINCOLN L.S.A.R. Self-Aligning Variable Speed Rotators.

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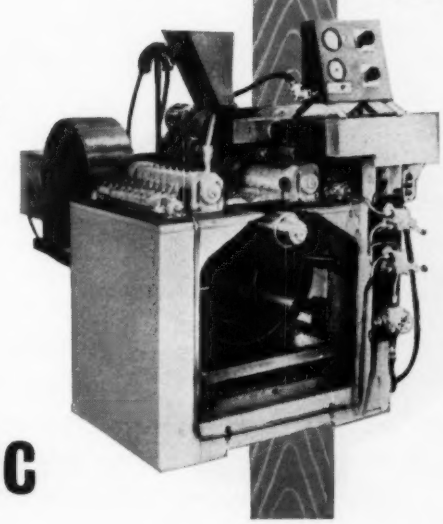

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MK 16TE DHB

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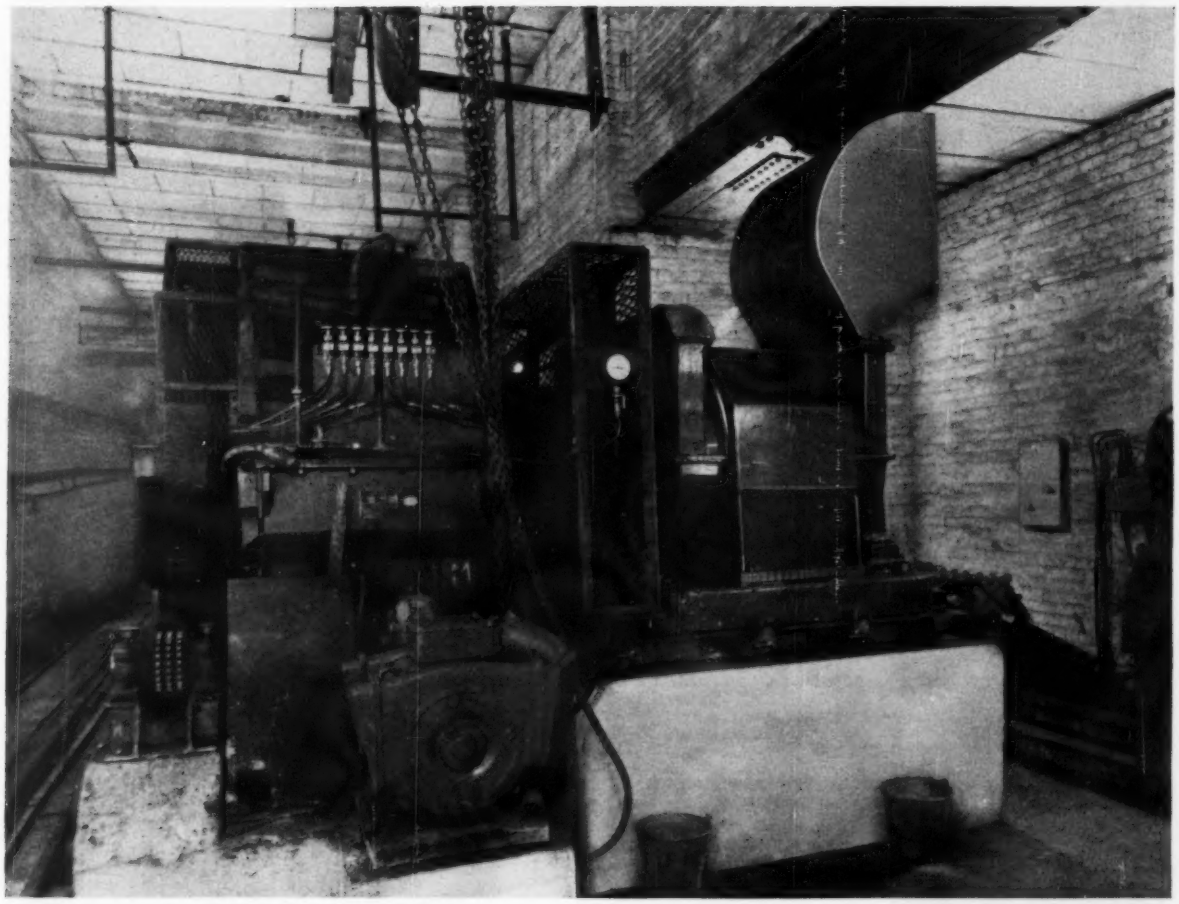

A 330 b.h.p., 3,300 v., 730 r.p.m. Mather and Platt drip-proof, double squirrel cage induction motor, with air filter, driving a cable belt conveyor in a coal mine in Scotland. The motor is of the low starting current type arranged for switching direct on the line, taking 3·65 times full load current, and is directly connected to the gearing which drives the cable belt. The small motor in the foreground is for driving at slow speed for rope inspection purposes.

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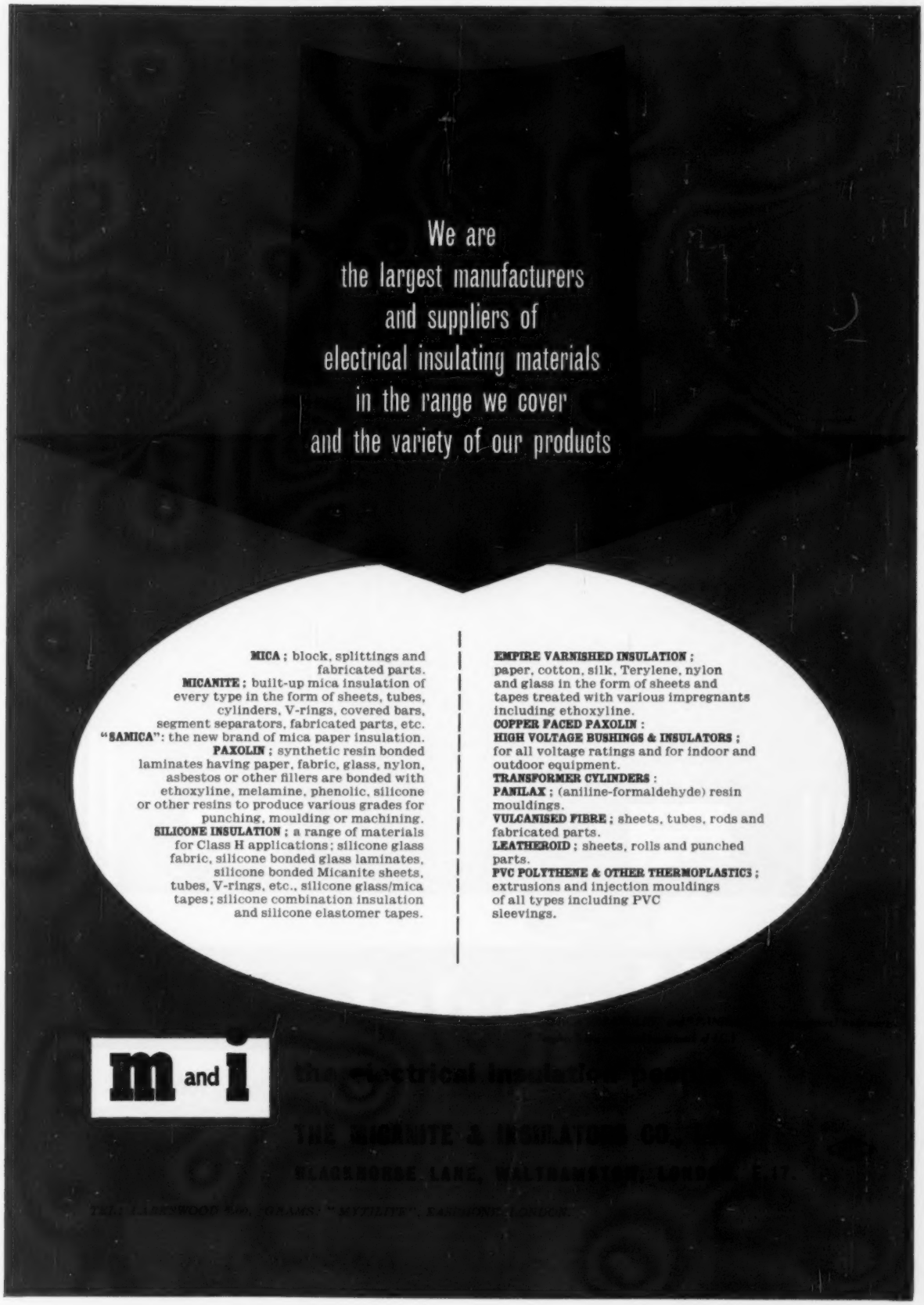
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MICANITE ; built-up mica insulation of every type in the form of sheets, tubes, cylinders, V-rings, covered bars, segment separators, fabricated parts, etc.
"SAMICA": the new brand of mica paper insulation.
PAXOLIN ; synthetic resin bonded laminates having paper, fabric, glass, nylon, asbestos or other fillers are bonded with ethoxyline, melamine, phenolic, silicone or other resins to produce various grades for punching, moulding or machining.
SILICONE INSULATION ; a range of materials for Class H applications; silicone glass fabric, silicone bonded glass laminates, silicone bonded Micanite sheets, tubes, V-rings, etc., silicone glass/mica tapes; silicone combination insulation and silicone elastomer tapes.
EMPIRE VARNISHED INSULATION ; paper, cotton, silk, Terylene, nylon and glass in the form of sheets and tapes treated with various impregnants including ethoxyline.
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HIGH VOLTAGE BUSHINGS & INSULATORS ; for all voltage ratings and for indoor and outdoor equipment.
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LEATHEROID ; sheets, rolls and punched parts.
PVC POLYTHENE & OTHER THERMOPLASTICS ; extrusions and injection mouldings of all types including PVC sleevings.
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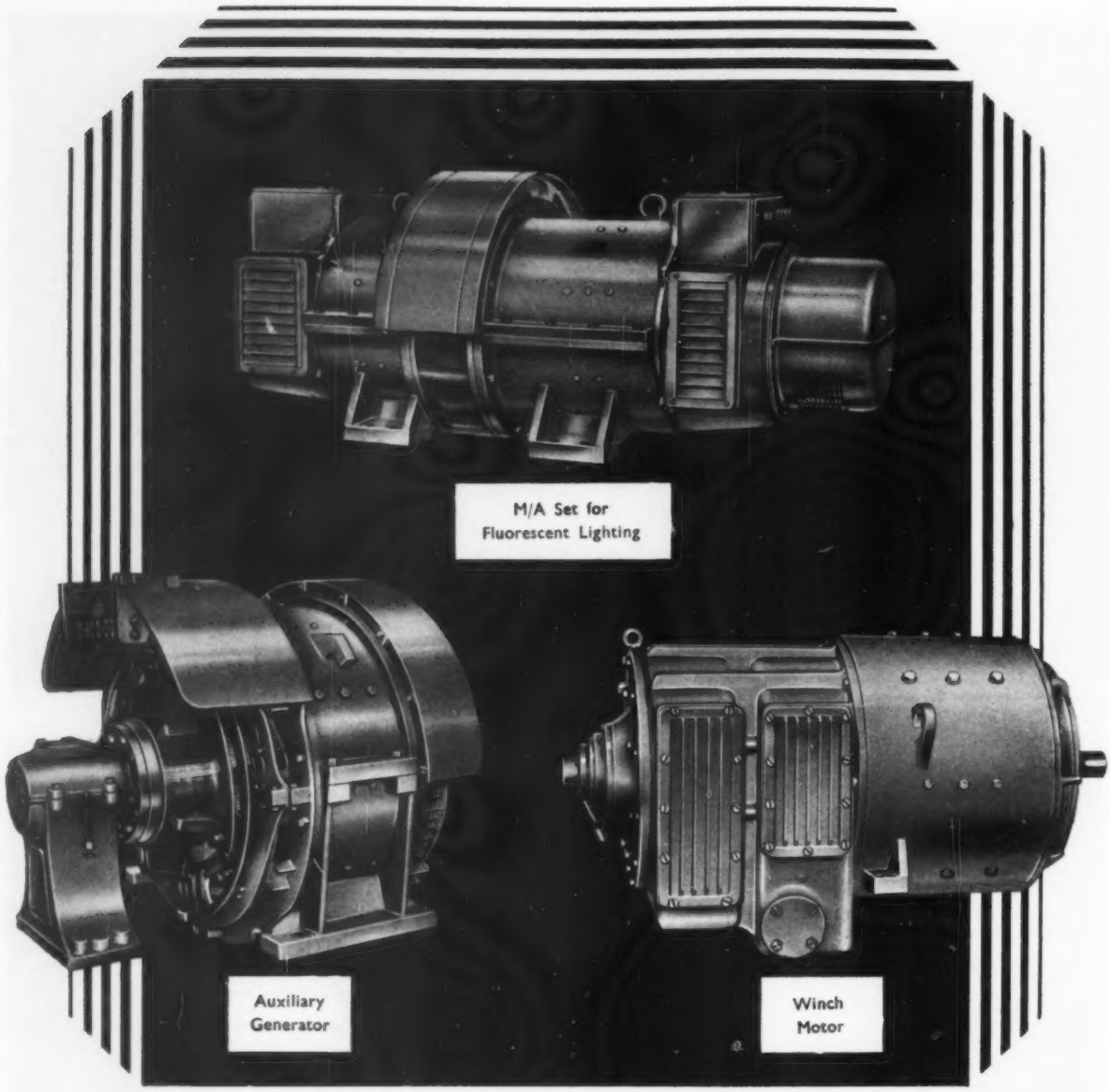

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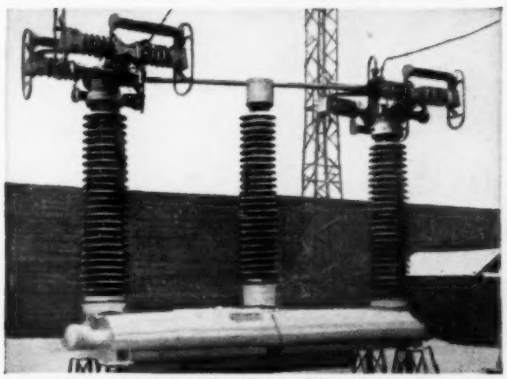

Metrovick are supplying 330 kV Air-Blast Switchgear with a breaking capacity of 10,000 MVA to the Snowy Mountains Hydro-Electric Authority and the Electricity Commission of New South Wales. The photograph shows one phase of a 330 kV breaker prepared for tests, resulting in the granting of ASTA certificate 3946.

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